Chapter 1.

Elementary and Secondary Mathematics and Science Education

Table of Contents

List of Sidebars

List of Tables

List of Figures

Highlights

Student Learning in Mathematics and Science

The National Assessment of Educational Progress (NAEP) mathematics assessment results show that average mathematics scores for fourth and eighth graders improved slightly in 2013, continuing a pattern of small but consistent increases since 2000.

- The average mathematics score of U.S. fourth graders increased by 14 points from 2000 to 2007, leveled off between 2007 and 2009, and then rose by 2 points from 2009 to 2013.
- Among U.S. eighth graders, the average mathematics score increased continually from 2000 to 2013, with a total gain of 12 points over the period.

Overall mathematics scores for twelfth graders improved slightly between 2005 and 2013.

- Between 2005 and 2013, the average mathematics score for students in grade 12 increased by 3 points.

Although the percentage of fourth, eighth, and twelfth grade students achieving a level of proficient or higher on NAEP mathematics assessments increased between 2000 and 2013, those percentages stayed well below the 50% mark.

- The percentage of students in grade 4 achieving a level of proficient or higher increased from 24% in 2000 to 42% in 2013.
- The share of grade 8 students at or above the proficient level rose by 10 percentage points to 36% from 2000 to 2013.
- The percentage of all students in grade 12 who were at or above the proficient level in 2013 stood at 26%.

Between-group differences in mathematics NAEP performance based on parent education and race or ethnicity have persisted over time but narrowed slightly since NAEP testing began in 1978.

- The average score for 9-year-old students in 2012 was 252 for white students, 226 for black students, and 234 for Hispanic students.
- The average score for 13-year-old students with at least one parent who graduated from high school was 270 in 2012, compared with a score of 296 for students with at least one parent who graduated from college.
- For 13-year-olds, the gap between black and white students narrowed by 13 points between 1978 and 2012.

Overall, students from disadvantaged backgrounds continue to lag behind their more advantaged peers, with these disparities starting as early as kindergarten.

- Scores on the Early Childhood Longitudinal Study, Kindergarten Class of 2010–11 (ECLS-K:2011), mathematics assessment show that students with parents who did not graduate high school scored 21, compared with 36 for students with at least one parent with a graduate degree.
- Students whose family income was at or below the Federal Poverty Level averaged a score of 24, whereas students whose family income was at or above 200% of the poverty line had an average score of 33.

- At the high school level, the percentage of students who were proficient at level-5 mathematics skills increased by 5 points from grade 9 to grade 11 among students whose parents graduated from high school, with gains of 7, 16, and 23 points for students whose parents had an associate's, bachelor's, or advanced degree, respectively.

In the international arena, the Program for International Student Assessment data show that the U.S. average mathematics and science literacy scores are below the average scores for all developed countries, and the United States has substantially fewer high scores and more low scores than other developed countries.

- U.S. students' average mathematics score of 481 in 2012 was lower than the average score for all developed countries, 501.
- The average science literacy score for U.S. students in 2012 was 497, lower than the average science score of 511 for all developed countries.
- The United States appreciably underproduces students in the highest levels of mathematics achievement relative to other developed countries.
- The United States also moderately underproduces students in the highest levels of science achievement and, to an extent, overproduces students in the lowest levels of mathematics and science achievement.

High School Coursetaking in Mathematics and Science

The majority of high school students are on track to finish algebra 2 and basic science courses by the end of eleventh grade.

- As of 2012, 69% of current eleventh graders (who were ninth graders in 2009) were enrolled in algebra 2 or a more advanced mathematics course.
- In 2009, 39% of ninth graders enrolled in biology. In 2012, 41% of these students, now in grade 11, were enrolled in another basic science course, chemistry, or physics.

The number of students who take Advanced Placement (AP) courses in mathematics and science continues to rise.

- The number of students who took an AP exam in mathematics or science rose from 273,000 in 2003 to 527,000 in 2013.
- Despite these increases, only 17% of high school graduates took an AP mathematics or science exam, and 10% passed.

Teachers of Mathematics and Science

The majority of K−12 mathematics and science teachers held a teaching certificate and had taught their subjects for 3 years or more.

- In 2011, the vast majority of public middle and high school mathematics and science teachers (91% and 92%, respectively) were fully certified (i.e., held regular or advanced state certification).
- Fully certified mathematics and science teachers were less prevalent in high-minority and high-poverty schools when compared with schools with more advantaged students. For example, 88% of mathematics teachers in high-poverty schools were fully certified, compared with 95% of those in low-poverty schools.

- In 2011, some 85% of public middle and high school mathematics teachers and 90% of science teachers had more than 3 years of experience.

Fully certified, well-prepared, and experienced teachers were not evenly distributed across schools or classes.

- In 2011, for example, 75% of middle school mathematics teachers in low-poverty schools had in-field degrees, compared with 63% of teachers at high-poverty schools.
- At the high school level, 95% of mathematics teachers at low-poverty schools had in-field degrees, compared with 87% at high-poverty schools.

Working conditions were also not evenly distributed across schools.

- Fully 60% of mathematics teachers at high-poverty schools reported student misbehavior interfering with teaching, compared with just over one-third in low-poverty schools.
- For example, about 55% of mathematics and science teachers at high-poverty schools reported that students' tardiness and class cutting interfered with teaching, compared with 37% of teachers at low-poverty schools.

Instructional Technology and Digital Learning

The use of instructional technology in K−12 classrooms has been growing at a rapid pace, but teachers report that resources are still not adequate.

- In 2009, 97% of K–12 public school teachers reported that they had one or more computers in their classroom, and 69% said that they or their students often or sometimes used computers during class time.
- In 2012, 55% of K–12 teachers reported that there were not enough computers for student use in their classes.

The number of students participating in online learning is also rising.

- Full-time enrollment in online schools has grown from approximately 200,000 students in 2009–10 to more than 315,000 in 2013–14.
- In 2009–10, there were an estimated 1,816,400 enrollments in distance-education courses in K–12 public school districts, representing a 473% increase from 317,100 distance-education enrollments in the 2002–03 school year.

Transition to Higher Education

Since 2006, U.S. on-time high school graduation rates have improved steadily.

- In 2006, 73% of public high school students graduated on time with a regular diploma; by 2012, the figure had climbed to 81%.
- Black and Hispanic students had the highest gains, from 61% to 76% for Hispanic students and from 59% to 68% for black students.

Significant racial and ethnic and sex differences persisted, however, with white, Asian or Pacific Islander, and female students having higher graduation rates than their counterparts.

- In 2012, the on-time graduation rate for male students lagged behind that for female students by 7 percentage points (78% versus 85%).
- In 2012, the on-time high school graduation rates for Asian or Pacific Islander and white students were 93% and 85%, respectively; both of these figures surpassed those of black, Hispanic, and American Indian or Alaska Native students (68%–76%).

Immediate college enrollment rates have increased for all students from 1975 to 2013, though differences remain for demographic groups.

- Between 1975 and 2013, the percentage of high school graduates making an immediate transition to college increased from 51% to 66%.
- In 2013, the immediate college enrollment rate of students from low-income families was 33 percentage points lower than the rate of those from high-income families (46% versus 79%).
- Enrollment rates also varied widely with parental education, ranging in 2013 from 43% for students whose parents had less than a high school education to 83% for students whose parents had a bachelor's or higher degree.

American college enrollment rates are higher than the average rate for college enrollment internationally.

- The percentage of American young adults enrolling in university-level education for the first time was 71% in 2012, surpassing the Organisation for Economic Co-operation and Development (OECD) average of 58%.
- The United States ranked eighth out of the 33 countries that participated in the OECD study in 2012.

Introduction

Chapter Overview

Concern about the ability of the United States to compete in the global economy has lent urgency to calls for reform of science, technology, engineering, and mathematics (STEM) education. Federal and state policymakers and legislators have called for national efforts to develop strong STEM pathways from high schools to colleges that eventually will expand the STEM-capable workforce in the United States. At the K–12 level, reform efforts to improve mathematics and science learning have included increasing advanced coursetaking in these areas, promoting early participation in gatekeeper courses such as algebra 1, recruiting and training more mathematics and science teachers, and expanding secondary education programs that prepare students to enter STEM fields in college.

Educators have joined in a state-led effort to develop common national K–12 mathematics and science standards, as well as assessments and indicators for monitoring progress in K–12 mathematics and science teaching and learning. So far, a majority of states have adopted and are implementing the Common Core State Standards, whereas 12 states have adopted the Next Generation Science Standards (see sidebar The Context and Content of National K-12 Mathematics and Science Standards). Considerable attention is being paid to ensure that career and college readiness standards include a strong focus on STEM education (Achieve Inc. 2013; NCEE 2013; Pellegrino and Hilton 2012), and a recent National Research Council report established 14 progress indicators that can be used to monitor STEM progress in the K-12 education system and inform decisions about improving it (NRC 2013). [i]

Following a 2011 report by the National Research Council (NRC) on successful K–12 education in STEM fields, Congress asked the National Science Foundation (NSF) to identify methods for tracking progress toward the report's recommendations. In response, a committee convened by the NRC authored a second report describing a set of 14 progress indicators related to students' access to quality learning, educators' capacity, and policy and funding initiatives in STEM. This second NRC report *Monitoring Progress Toward Successful K-12 STEM Education* (2013), addresses the need for research and data that can be used to monitor progress in the K–12 STEM education system and for making informed decisions about improving it. The recommended indicators provide a framework for Congress and relevant federal agencies to create and implement a national-level monitoring and reporting system that could support progress towards the NRC's three goals for U.S. K-12 education in the STEM disciplines. More information about the indicators can be found at http://stemindicators.org.

The Context and Content of National K-12 Mathematics and Science Standards

The Common Core State Standards (CCSS) and Next Generation Science Standards (NGSS) are the latest developments in a tradition of standards-based education reform that has become a focal point of education reform in the United States. This reform tradition can be traced back to *A Nation at Risk*, which argued that student achievement in the United States was falling behind that of other nations because of inadequacies in its education system (Gardner 1983). President George H.W. Bush convened the first national education summit in Charlottesville, Virginia, in 1989, an event that led to the articulation of six long-term reform goals (Klein 2014). The Charlottesville summit inspired each successive president to promote the development and adoption of standards and assessments through national legislation: President Clinton with the Goals 2000: Educate America Act and the Improving America's Schools Act of 1994, President George W. Bush with the No Child Left Behind Act of 2001, and President Barack Obama with the Race to the Top Fund initiated in 2009 (Klein 2014).

Independent national organizations of educators developed their own sets of standards for science and math education, beginning with the influential *Curriculum and Evaluation Standards for School Mathematics* published by the National Council of Teachers of Mathematics in 1989 (AAAS 1993; NCTM 1989, 2000; NRC 1996). Standards for learning in science and other subjects followed. Many states have used these national standards as models in developing their own standards, although their implementation has varied substantially among states (Shepard, Hannaway, and Baker 2009; Weiss 2000).

In 2009, the National Governors Association Center for Best Practices, the Council of Chief State School Officers, and Achieve Inc. coordinated an effort to develop CCSS in English language arts and mathematics. Since their 2010 release, the CCSS have received acclaim and criticism from educators, policymakers, and education advocates. Although nearly every state signed on to the CCSS initially, support has declined as implementation has progressed (Rentner and Kober 2014). In 2013, Indiana, South Carolina, and Oklahoma reversed their Common Core adoptions, and several other states are reviewing and possibly repealing the Common Core standards (Salazar and Christie 2014; Ujifusa 2014).

The status of CCSS-aligned assessments is even less certain. In 2010, the U.S. Department of Education funded two consortia of states, the Smarter Balanced Assessment Consortium and the Partnership for Assessment of Readiness for College and Careers, to create assessments aligned with the CCSS. States with voting power in the consortia had to agree to implement the assessments by the 2014–15 school year. In addition to federally funded efforts, states such as Kentucky and New York have sought to develop their own CCSS-aligned assessments, as have commercial testing corporations. Many states have experienced difficulties in implementing CCSS-aligned assessments.

The NGSS, released in 2013, were developed by Achieve Inc., the National Research Council, the National Science Teachers Association, and the American Association for the Advancement of Science in conjunction with 26 states. The NGSS have stirred less controversy than the CCSS but have been adopted by fewer states (Heitin 2014b). States have reported that they are too busy implementing CCSS to implement the new science standards simultaneously (Heitin 2014a). In addition, adoption and implementation of NGSS have not been tied to financial incentives as they have been for CCSS (Heitin 2014a).

Chapter Organization

To provide a portrait of K−12 STEM education in the United States, including comparisons of U.S. student performance with that of other nations, this chapter compiles indicators of precollege mathematics and science teaching and learning based mainly on data from the National Center for Education Statistics (NCES) of the U.S. Department of Education, supplemented by other public sources. Table 1-1 contains an overview of the topics covered in this chapter and the indicators used to address them.

Table 1-1 **Indicators of elementary and secondary school mathematics and science education**

Chapter 1. **Elementary and Secondary Mathematics and Science Education**

Topic	Indicator
Student learning in mathematics and science	• Mathematics and science performance of first-time kindergarten students in the 2010–11 and 2011–12 school years • Trends in fourth, eighth, and twelfth graders' mathematics performance through 2013 • Algebra performance of 2009 ninth graders when they were in ninth and eleventh grades (2009 and 2012) • International comparisons of 15-year-olds' mathematics and science literacy in 2012
Student coursetaking in mathematics and science	• Highest mathematics and science course enrollment of eleventh graders in 2012 • Trends in participation and performance in Advanced Placement program from 2003 to 2013
Teachers of mathematics and science	• Degrees, certification, subject-matter preparation, and experience of mathematics and science teachers in 2012 • Professional development of mathematics and science teachers in 2012 • Salaries and working conditions of mathematics and science teachers in 2012
Instructional technology and digital learning	• Review of emerging practices of instructional technology and distance education and their effects on student learning
Transitions to higher education	• Trends in on-time high school graduation rates from 2006 to 2012 • International comparisons of secondary school graduation rates in 2012 • Immediate college enrollment from 1975 to 2013 • Choice of STEM majors among U.S. undergraduate students in the 2011–12 academic year • International comparisons of college enrollment rates in 2012

STEM = science, technology, engineering, and mathematics.

Science and Engineering Indicators 2016

This chapter is organized into five sections. The first section presents indicators of U.S. students' performance in STEM subjects in elementary and secondary school. It begins with a review of national trends in scores on mathematics and science assessments in grades 4, 8, and 12. Next, it presents data from two longitudinal studies that track individual students' growth in mathematics and science knowledge over time: the Early Childhood Longitudinal Study, Kindergarten Class of 2010–11 (ECLS-K:2011), and the High School Longitudinal Study of 2009 (HSLS:09). The section ends by placing U.S. student performance in an international context, comparing the mathematics and science literacy of U.S. 15-year-olds with that of their peers in other countries.

The second section focuses on mathematics and science coursetaking in high school. Using data from HSLS:09, data from the College Board's Advanced Placement (AP) program, and data collected by the U.S. Department of Education's Office of Civil Rights (OCR), it examines high school students' participation in mathematics and science courses.

The third section turns to U.S. elementary, middle, and high school mathematics and science teachers, examining their experience, licensure, subject-matter preparation, professional development, salaries, and working conditions. All teacher indicators in this section use the latest available data, derived from the NCES 2011–12 Schools and Staffing Survey (SASS).

The fourth section examines how technology is used in K−12 education. The section begins by presenting the latest national data on the availability or use of various technological devices in classrooms, Internet access in schools, and the prevalence of online learning among K–12 students. It then provides a review of research on the effectiveness of technology as an instructional tool to improve student learning outcomes.

The fifth section focuses on indicators related to U.S. students' transitions from high school to postsecondary education. It presents national data for on-time high school graduation rates, long-term trends in immediate college enrollment after high school, transition to STEM fields at the postsecondary level, and academic preparation for college. This section also examines the high school graduation and postsecondary entry rates of U.S. students relative to those of their peers in other countries. Together, these indicators present a broad picture of the transition of U.S. students from high school to postsecondary education, the topic of chapter 2.

This chapter focuses on overall patterns and also reports variation in access to educational resources by schools' minority concentrations and poverty levels and in student performance by sex, race or ethnicity, and family and school characteristics. Whenever a comparative statistic is cited in this chapter, it is statistically significant at the 0.05 probability level.

Student Learning in Mathematics and Science

Increasing academic achievement for *all* students—with an emphasis on improving the performance of low-achieving students—is a critical goal of education reform in the United States. Many educators and policymakers focus on improving student learning in STEM subjects because workers' proficiency in STEM fields is considered vital to the health of the economy (Atkinson and Mayo 2010; PCAST 2012). This section presents indicators of U.S. students' performance in STEM subjects in elementary and secondary school. It begins with a review of national trends in scores on mathematics assessments, using data from the National Assessment of Educational Progress (NAEP). Next, it presents data from two longitudinal studies that track individual students' growth in mathematics and science knowledge over time: ECLS-K:2011 and HSLS:09. The section ends by placing U.S. student performance in an international context, comparing the mathematics and science literacy of U.S. 15-year-olds with that of their peers in other countries.

The data from these various sources reveal several key findings. Students' scores on mathematics assessments show some small improvements, continuing a pattern of small but consistent increases over time. Proficiency levels have also improved but remain below 50% for all age groups. Data for the nation's elementary and high school students reveal that achievement gaps in mathematics continue to persist for students from disadvantaged backgrounds, and international assessments reveal that the United States lags behind other developed countries in average mathematics and science literacy scores.

National Trends

This subsection looks at trends in U.S. students' achievement in mathematics over time, presenting estimates from the NAEP. Two NAEP data collections contribute to this discussion: data from the main NAEP demonstrate changes since 1990 in the mathematics performance of students in grades 4, 8, and 12, whereas NAEP long-term trend (LTT) data allow examination of the mathematics performance of 9-, 13-, and 17-year-old students since 1973. This section's analysis includes new mathematics data from the main NAEP 2013 and the NAEP LTT 2012. New science data were not available for analysis in this edition. The most recent available findings based on NAEP science data have been reported in previous editions of *Science and Engineering Indicators* (NSB 2012, 2014).

Although the main NAEP and the NAEP LTT both assess mathematics, there are several differences between them, particularly in the content assessed, how often the assessment is administered, and how the results are reported. These and other differences mean that results from the main NAEP and the NAEP LTT cannot be compared directly. The main NAEP content frameworks and assessments are updated periodically to reflect changes in contemporary curriculum standards, whereas the NAEP LTT content frameworks in science and mathematics have remained the same since about 1970.[i] The following analyses of national trends used cross-sectional data from the main NAEP to examine recent performance and from the NAEP LTT to examine trends going back to 1978.

Reporting Results for the Main NAEP

The main NAEP reports student performance in two ways: scale scores and student achievement levels. Scale scores, designed to measure student mathematics learning, range from 0 to 500 for grades 4 and 8 and from 0 to 300 for grade 12. Student achievement levels developed by the National Assessment Governing Board, with broad input from the public, educators, and policymakers, indicate the extent of students' actual achievement expected for a particular grade level. The three grade-specific achievement levels for mathematics (NAGB 2010) are the following:

- *Basic:* partial mastery of materials
- *Proficient:* solid academic performance
- *Advanced:* superior academic performance

Mathematics Performance of Students in Grades 4 and 8 from 2000 to 2013

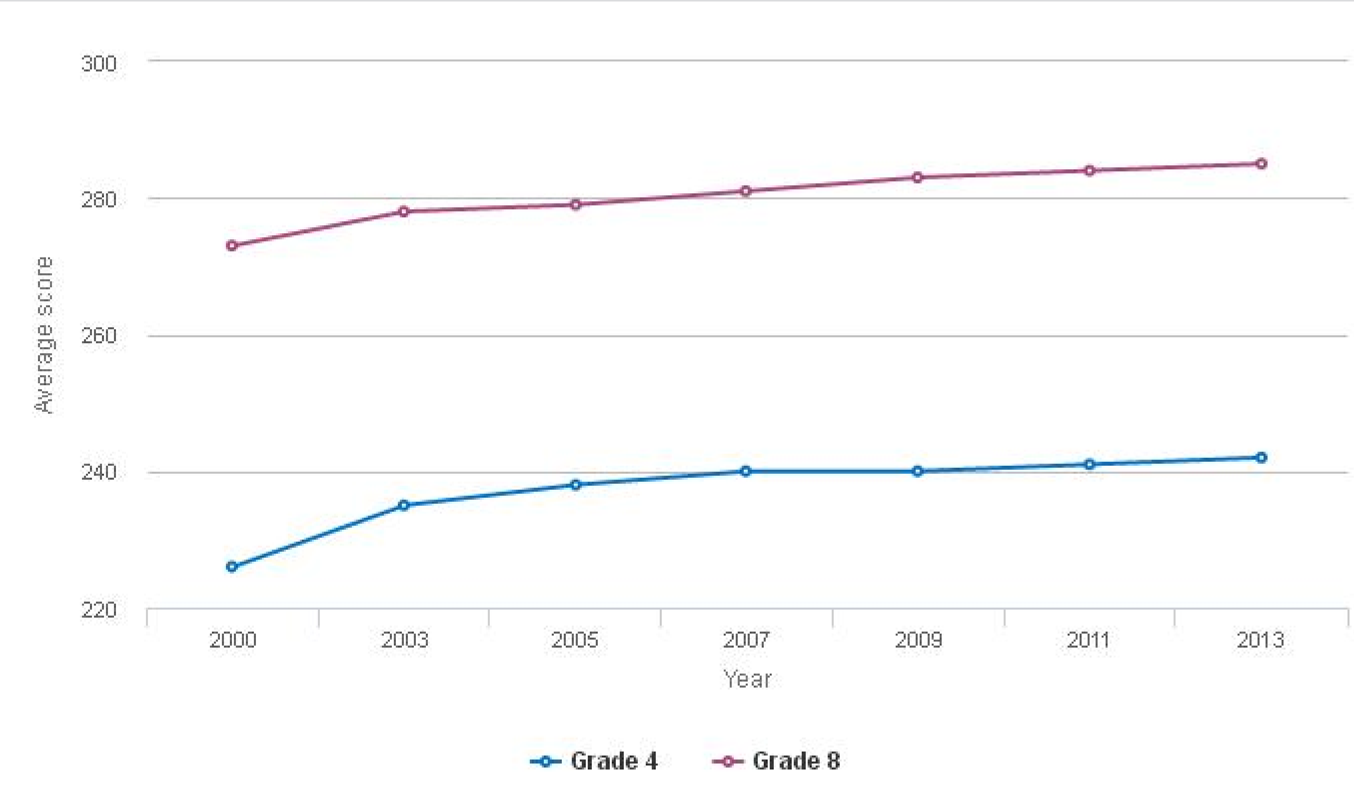
Average score. The average mathematics score of U.S. fourth graders increased by 14 points from 2000 to 2007, leveled off between 2007 and 2009, and then rose by 2 points from 2009 to 2013 (Figure 1-1). This overall trend was reflected in almost all demographic groups. For example, from 2000 to 2007, the fourth grade average mathematics score increased by 14 points for white students, 19 points for black students, 19 points for Hispanic students, and 20 points for American Indian or Alaska Native students (Appendix Table 1-1). Average scores for these racial and ethnic groups generally remained unchanged between 2007 and 2009 and then increased by 2 to 4 points from 2009 to 2013.

---

[i] The science framework was established in 1969, and the mathematics framework was created in 1973.

Figure 1-1

Average NAEP mathematics scores of students in grades 4 and 8: 2000–13



NAEP = National Assessment of Educational Progress.

NOTE: NAEP mathematics assessment scores range from 0 to 500 for grades 4 and 8.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2014) of NAEP 2000, 2003, 2005, 2007, 2009, 2011, and 2013 mathematics assessments, National Center for Education Statistics. See appendix table 1-1.

Science and Engineering Indicators 2016

Among U.S. eighth graders, the average mathematics score increased continually from 2000 to 2013, with a total gain of 12 points over the period (Figure 1-1). Continual improvement was seen in almost all demographic groups. Gains were particularly apparent for several groups, including blacks, Hispanics, and Asians or Pacific Islanders, with score increases of 18–19 points from 2000 to 2013 (Appendix Table 1-1).

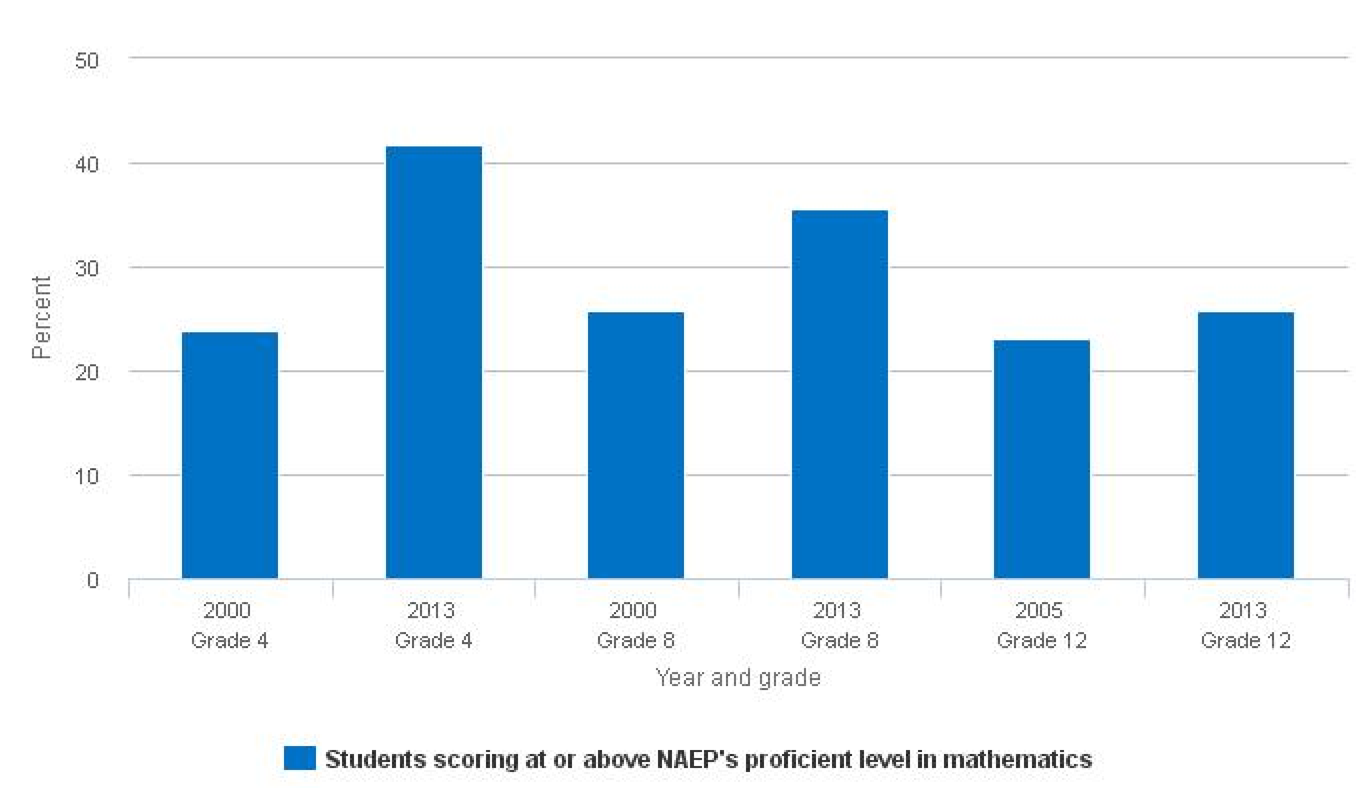
For grade 12, only 2005, 2009, and 2013 results are examined here. Substantial revisions of the mathematics framework for the 2005 assessment made comparison with earlier assessments impossible. Between 2005 and 2013, the average mathematics score for students in grade 12 increased by 3 points (Appendix Table 1-1). Improvement occurred in many groups during this period, ranging from 5 points among several groups to 9 points for Asian or Pacific Islander students and 13 points for those of two or more races. Only English language learners' scores decreased during the period, dropping by 11 points.

Proficiency level. Increases in the percentages of students in grade 4 who achieved a level of proficient or higher in mathematics parallel the average scale score improvements (Appendix Table 1-2). Although the percentage of grade 4 students reaching proficiency or better did increase, it stayed well below the 50% targeted by the standards. Specifically, 42% of students in grade 4 achieved a level of proficient or advanced in 2013, up from 24%

in 2000 (Figure 1-2). In 2013, white and Asian or Pacific Islander students scored above the 50% mark, at 54% and 64%, respectively. Scores for students in other demographic groups were much lower, with just 18% of black students, 26% of Hispanic students, 24% of American Indian or Alaska Native students, 26% of students eligible for free/reduced-price lunch, and 14% of English language learners performing at or above the proficient level (Appendix Table 1-2).

Figure 1-2

Students in grades 4, 8, and 12 scoring at or above NAEP's proficient level in mathematics for their grade: 2000, 2005, and 2013



NAEP = National Assessment of Educational Progress.

NOTE: Grade 12 mathematics data are presented for 2005 and 2013 because the mathematics framework was substantially revised in 2005, making prior assessment results not comparable with those in or after 2005.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2014) of NAEP 2000, 2005, and 2011 mathematics assessments, National Center for Education Statistics. See appendix table 1-2.

Science and Engineering Indicators 2016

The share of grade 8 students at or above the proficient level rose by 10 percentage points, to 36%, from 2000 to 2013 (Figure 1-2). Changes between 2000 and 2013 for most groups were in the range of 8–13 percentage points; however, Asians or Pacific Islanders gained 19 percentage points, and 60% of them performed at or above the proficient level in 2013. English language learners gained just 3 percentage points, with only 5% reaching the proficient level in 2013 (Appendix Table 1-2).

The percentage of all students in grade 12 who were at or above the proficient level in 2013 stood at 26%, below that of eighth graders (36%) and fourth graders (42%) (Figure 1-2). Changes between 2005 and 2013 were generally in the range of 2–4 percentage points, and only Asians or Pacific Islanders were moderately near the 50% mark (Appendix Table 1-2).

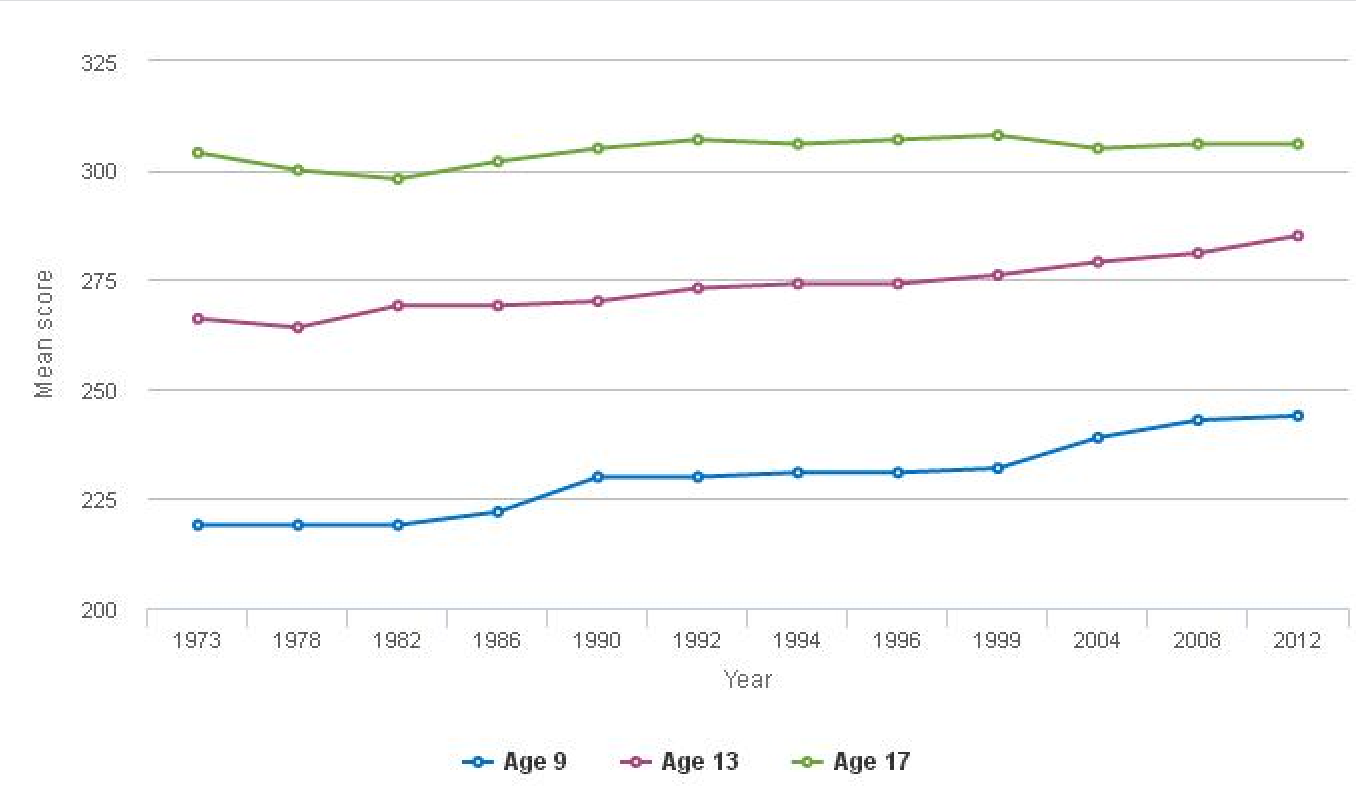
Trends in Mathematics Performance since 1973

NAEP LTT data provide comparable average scores in mathematics for students ages 9, 13, and 17 beginning in 1973.[ii] This section discusses mathematics results from two points in time—1973 and 1978. Although the first LTT mathematics assessment was administered in 1973, very few of the items were included in subsequent assessments. Thus, 1978 is the primary start of the LTT assessment in mathematics. However, NCES was able to extrapolate data to compare the average scores of the 1973 assessment with later assessments, so some comparisons can be made to 1973. NAEP LTT scores range from 0 to 500. The scores exhibit different patterns for each age group. For 9-year-olds, the scores are flat in the 1970s, rise through the late 1980s, remain flat through the 1990s, and then rise again. The scores of 13-year-olds increased at a gradual pace over that same time, but those of 17-year-olds went flat after about 1990 and remained unchanged (Figure 1-3). The 2012 mathematics average for 9-year-old students (244) was 25 points higher than that in 1978; 13-year-old students gained 21 points, to 285, in the same period. The score trends for different demographic groups closely followed these same patterns.

[ii] Estimates for 1973 were extrapolated.

Figure 1-3

Average NAEP LTT mathematics assessment scores of students ages 9, 13, and 17: 1973–2012



NAEP = National Assessment of Educational Progress; LTT = long-term trend.

NOTE: NAEP LTT mathematics assessment score ranges from 0 to 500 for students in all ages.

SOURCES: Rampey B, Dion G, Donahue P, *NAEP 2008 Trends in Academic Progress*, NCES 2009-479 (2009), figures 10–12; National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2014) of NAEP LTT 2012 mathematics assessments, National Center for Education Statistics. See appendix table 1-3.

Science and Engineering Indicators 2016

As shown in Appendix Table 1-3, students in demographic groups identified by sex, highest level of parent education, and race or ethnicity also improved their performance over time. Between 1978 and 2012, the average score for 9-year-old male students increased from 217 to 244, and the average score for 9-year-old female students increased from 220 to 244. The average score for 9-year-old students increased from 224 to 252 for white students, from 192 to 226 for black students, from 203 to 234 for Hispanic students, and from 229 to 265 for Asian or Pacific Islander students. The average score for 13-year-old students with at least one parent who graduated from high school was 263 in 1978 and 270 in 2012. The average score for 13-year-old students with at least one parent who graduated from college was 284 in 1978 and 296 in 2012. Average scores for 17-year-old students changed moderately for all groups, with the exception of Hispanic and black students, whose scores increased by 18 and 20 points, respectively, between 1978 and 2012.

Performance gaps. NAEP LTT data indicate that, although between-group differences in mathematics performance observed in 1978 have persisted, many of these gaps were significantly smaller in 2012 than in 1978 (Table 1-2). The gap between black students and white students at age 9 was 6 points narrower in 2012 than in 1978. All other gaps in mathematics performance at age 9 by race and ethnicity were the same in 2012 as in 1978. For

13-year-olds, the gap between black students and white students narrowed by 13 points, and the gap between Hispanic students and white students narrowed by 12 points. For 17-year-olds, the gap in mathematics scores between black students and white students narrowed by 12 points and the gap between Hispanic students and white students was reduced by 10 points.

Table 1-2 Magnitude of changes in NAEP LTT mathematics assessment score gaps, by race or ethnicity and parents' highest education: 1978–2012

Score gap	Age 9	Age 13	Age 17
Race or ethnicity			
Blacks and whites	-6	-13	-12
Hispanics and whites	≈	-12	-10
Asians and whites	≈	16	≈
Asians and blacks	≈	≈	-15
Asians and Hispanics	≈	≈	-13
Parents' highest education			
Did not finish high school and graduated from high school	NA	-14	-13
Did not finish high school and had some college	NA	-8	-9
Did not finish high school and graduated from college	NA	-9	-10
Graduated from high school and had some college	NA	6	4
Graduated from high school and graduated from college	NA	5	≈
Had some college and graduated from college	NA	≈	≈

NOTES: ≈ = no change; NA = not available.

NAEP = National Assessment of Educational Progress; LTT = long-term trend.

Hispanic may be any race. Asian, black or African American, and white refer to individuals who are not of Hispanic origin. NAEP LTT mathematics assessment scores range from 0 to 500 for students of all ages.

SOURCES: Rampey B, Dion G, Donahue P, *NAEP 2008 Trends in Academic Progress*, NCES 2009-479 (2009), figures 10–12; National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2014) of NAEP LTT 2012 mathematics assessments, National Center for Education Statistics. See appendix table 1-3.

Science and Engineering Indicators 2016

Gender gaps. Between 1978 and 2012, there was no consistent gap between the mathematics scores of male and female students at either age 9 or age 13 (Appendix Table 1-3). Among 17-year-old students, however, the NAEP LTT data suggest the existence of a small gap between male and female students in most years between 1978 and 2012, a gap that was not significantly different in 2012 from what it was in 1978. The average scores in 1978 for male and female students were 304 and 297, respectively. In 2012, the average scores for male and female 17-year-old students were 308 and 304, respectively.

Student Development over Time: Longitudinal Data

The national trend data discussed thus far indicate how the performance of the nation's students at specific ages or education levels has changed over time. This section presents data from two nationally representative surveys that track individual students' growth in mathematics and science knowledge, assessing the same students' performance over time rather than querying successive different cohorts. ECLS-K:2011 data provide a look at young children's understanding of mathematics and science and how it changes in the first years of formal schooling. HSLS:09 data indicate how students' understanding of mathematics develops in the first 3 years of high school.

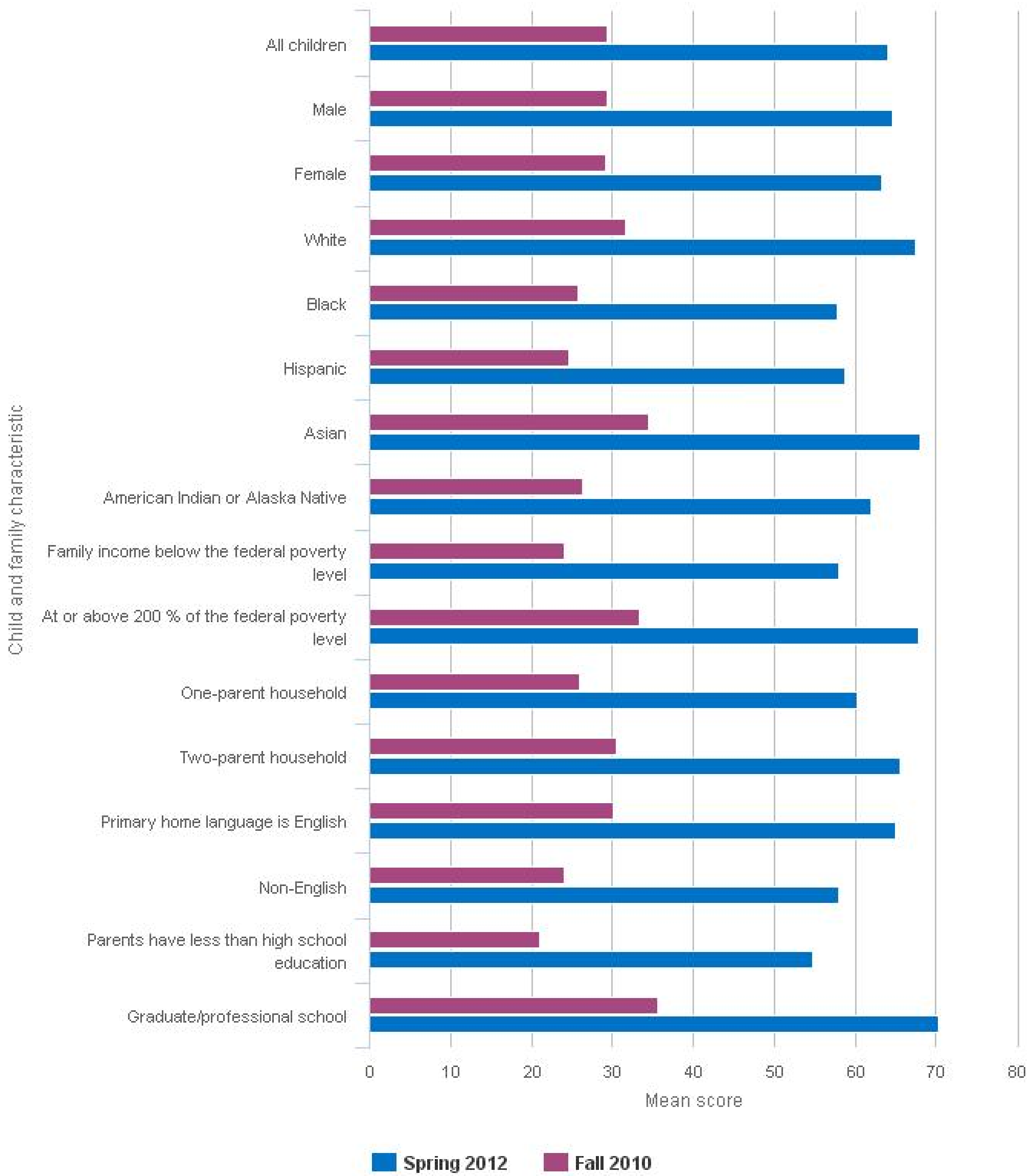
Mathematics and Science Knowledge in Early Childhood

ECLS-K:2011 is a nationally representative, longitudinal study of children's development, early learning, and school progress (Mulligan, Hastedt, and McCarroll 2012). Data for the ECLS-K:2011 study were first collected in fall 2010 from approximately 18,200 kindergarten students. ECLS-K:2011 will follow and test the same student sample each year until spring 2016, when most students will be in fifth grade. This section provides a snapshot of the children in the ECLS-K:2011 cohort who were in kindergarten for the first time in the 2010–11 school year and advanced to first grade in the following year. It compares students' mathematics scores from the beginning of kindergarten to the end of first grade. Science assessment results are only from the beginning and end of first grade, a shorter assessment period. Students' mathematics and science assessment results cannot be compared with each other because scales are developed independently for each subject. Both mathematics and science results show that students enter school with different levels of preparation and that those differences persist for students of different racial, ethnic, and socioeconomic groups, a finding that is supported in the research literature (Loeb and Bassok 2007; Magnuson and Duncan 2006).

Kindergarten performance on the ECLS-K mathematics assessment in fall 2010 varied by demographic characteristics (Figure 1-4). Boys' and girls' mathematics scores did not differ, with both scoring an average of 29. Among racial or ethnic groups, black and Hispanic students scored the lowest (26 and 25, respectively), and Asian students scored the highest (35). Students whose family income was at or below the Federal Poverty Level (FPL) scored 9 points lower than students whose family income was at or above 200% of the poverty line (24 versus 33). Score differences also existed between students from one- and two-parent homes (26 versus 31, respectively), students whose families spoke English at home or not (30 versus 24, respectively), and students whose parents had not graduated from high school and those whose parents had received a graduate-level degree (21 versus 36, respectively).

Figure 1-4

Average mathematics assessment test scores of children who were in kindergarten for the first time during the 2010-11 school year and in first grade during the 2011-12 school year, by child and family characteristics: Fall 2010 and spring 2012



NOTES: Hispanic may be any race. American Indian or Alaska Native, Asian, black or African American, and white refer to individuals who are not of Hispanic origin. Mathematics assessment scores range from 0 to 75 for kindergarteners and from 0 to 96 for first graders.

SOURCES: Mulligan GM, Hastedt S, McCarroll JC, *First-Time Kindergartners in 2010–11: First Findings From the Kindergarten Rounds of the Early Childhood Longitudinal Study, Kindergarten Class of 2010–11 (ECLS-K:2011)*, NCES 2012-049 (2012); Mulligan GM, McCarroll JC, Flanagan KD, Potter D, *Findings From the First-Grade Rounds of the Early Childhood Longitudinal Study, Kindergarten Class of 2010–11 (ECLS-K:2011)*, NCES 2015-109 (2014). See appendix table 1-4.

Science and Engineering Indicators 2016

Assessment scores for these students in spring 2012 show that the same performance gaps evident at kindergarten entrance persisted into the end of first grade. For example, the difference in scores between white and black students was 6 points in fall 2010 and 10 points in spring 2012; for Hispanic and white students, the gap was 7 points in fall 2010 and 9 points in spring 2012 (Appendix Table 1-4). Schooling did not close the achievement gap. The average mathematics assessment score for first graders was 64. Black and Hispanic students scored the lowest (58 and 59, respectively) compared to other racial or ethnic groups. Students with family incomes below the FPL, students from one-parent homes, students from non-English-speaking homes, and students whose parents had less than a high school education all scored lower than their counterparts.

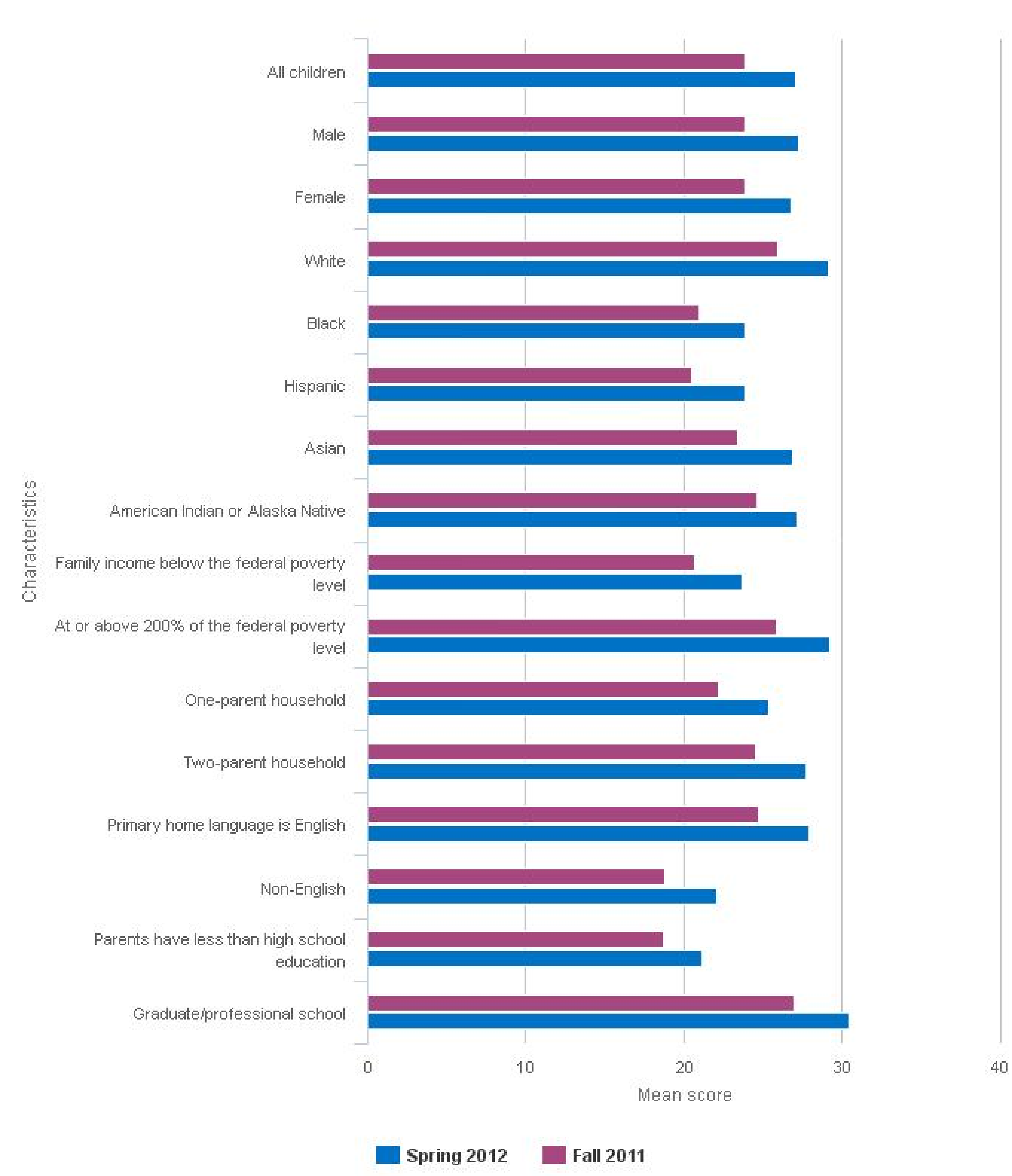
ECLS-K:2011 collected first grade science assessment data in fall 2011 and spring 2012.[i] The first grade science assessment included items about physical sciences, life science, environmental sciences, and scientific inquiry. First grade students' average score was 24 points on a 47-point scale in fall 2011 and 27 points in spring 2012 (Figure 1-5). Science assessment scores show the same pattern as mathematics scores, with achievement gaps evident at the beginning of first grade not closing by the end of the school year. Students from non-English-speaking homes, students with family income below the FPL, and students with parents with less than a high school education posted the lowest scores (Appendix Table 1-5).

---

[i] This analysis does not include results from the spring 2011 science assessment because they have not been reported by NCES (i.e., the ECLS-K:2011 First Look report did not include results from the kindergarten science assessment).

Figure 1-5

Average science assessment test scores of children who were in kindergarten for the first time during the 2010–11 school year and in first grade during the 2011–12 school year, by child and family characteristics: Fall 2011 and spring 2012



NOTES: Hispanic may be any race. American Indian or Alaska Native, Asian, black or African American, and white refer to individuals who are not of Hispanic origin. Science assessment score ranges from 0 to 47.

SOURCES: Mulligan GM, Hastedt S, McCarroll JC, *First-Time Kindergartners in 2010–11: First Findings From the Kindergarten Rounds of the Early Childhood Longitudinal Study, Kindergarten Class of 2010–11 (ECLS-K:2011)*, NCES 2012-049 (2012); Mulligan GM, McCarroll JC, Flanagan KD, Potter D, *Findings From the First-Grade Rounds of the Early Childhood Longitudinal Study, Kindergarten Class of 2010–11 (ECLS-K:2011)*, NCES 2015-109 (2014). See appendix table 1-5.

Science and Engineering Indicators 2016

Developing Algebra Skills in High School

Mastering the mathematics concepts and skills taught in the typical algebra 1 course allows high school students to take higher-level mathematics and more challenging college preparatory courses. Taking higher-level mathematics courses, in turn, is associated with positive academic outcomes beyond high school such as college attendance, college graduation, job readiness, and higher earnings (Achieve Inc. 2008; Adelman 2008; Bozick and Lauff 2007; Byun, Irvin, and Bell 2014; Gaertner et al. 2014; Gamoran and Hannigan 2000; Long, Conger, and Iatarola 2012; Nord et al. 2011). This discussion uses data from HSLS:09 to measure the development of students' understanding and skills in algebra as they move through high school.

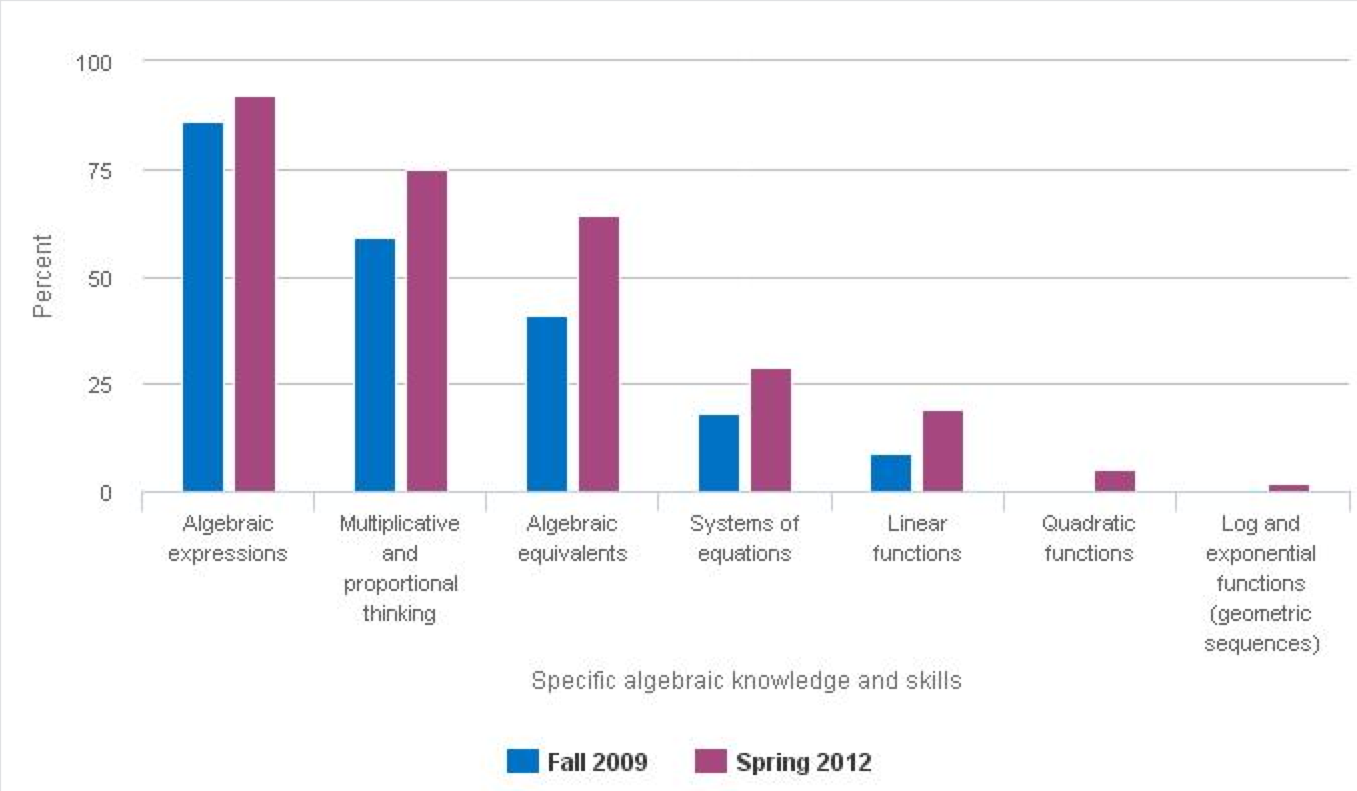
HSLS:09, a nationally representative longitudinal study, focuses on understanding students' trajectories from the beginning of high school into higher education and the workforce (Ingels et al. 2011). HSLS:09 pays particular attention to high school–level math and science education, the high school environment, and postsecondary education. The HSLS:09 sample of approximately 24,000 students was drawn from students who were in grade 9 in 944 schools across the United States during the 2008–09 academic year. Students were interviewed for the first follow-up survey more than 2 years later, when most were in eleventh grade. During both the base-year and first follow-up data collections, students completed a mathematics assessment of algebraic reasoning and problem solving. Science was not assessed, so it is not discussed in this section. The mathematics assessment provided indicators of the students' proficiency in hierarchical performance levels; that is, students proficient at any given level are considered proficient at all lower levels. The base-year algebra assessment included the following five algebraic proficiency levels:

- Level 1: The student understands algebra basics, including evaluating simple algebraic expressions and translating between verbal and symbolic representations of expressions.
- Level 2: The student understands proportions and multiplicative situations and can solve situation word problems involving proportions, find the percentage of a number, and identify equivalent algebraic expressions for multiplicative situations.
- Level 3: The student understands algebraic equivalents and can link equivalent tabular and symbolic representations of linear equations, identify equivalent lines, and find the sum of variable expressions.
- Level 4: The student understands systems of linear equations, can solve such systems algebraically and graphically, and can characterize the lines (parallel, intersecting, collinear) represented by a system of linear equations.
- Level 5: The student understands linear functions and can find and use slopes and intercepts of lines and functional notation.

HSLS:09 students were first assessed in ninth grade in fall 2009 and again at the end of eleventh grade in spring 2012. The percentage of students reaching proficiency at each of the five levels increased in 2012. Constrained by a ceiling effect, the smallest gain occurred in the percentage of students who were proficient at level 1, which increased from 86% in 2009 to 92% in 2012 (Figure 1-6). In 2012, three-fourths of students were proficient at multiplicative and proportional thinking, nearly two-thirds understood algebraic equivalents, almost 30% grasped systems equations, and about a fifth comprehended linear functions. These shares rose by 10–23 percentage points over the 3 years between 2009 and 2012. Although algebraic proficiency levels of male and female students progressed broadly in parallel, this was not the case for students from different demographic backgrounds. Socioeconomic status (SES), parental education level, and private school attendance were associated with greater proficiency gains (Appendix Table 1-6). For example, the percentage of students who were proficient at level 5 increased by 5 points among students whose parents graduated from high school, with gains of 7, 16, and 23 points for students whose parents had an associate's, bachelor's, or advanced degree, respectively. High SES and private-school attendance provided a similar advantage in level-5 proficiency score gains.

Figure 1-6

Fall 2009 students in grade 9 who were proficient in specific algebraic knowledge and skills in fall 2009 and spring 2012



NA = not available; quadratic functions and log and exponential functions were not tested in fall 2009.

SOURCES: Ingels SJ, Dalton B, Holder TE, Lauff E, Burns LJ, *High School Longitudinal Study of 2009 (HSLS:09): A First Look at Fall 2009 Ninth-Graders*, NCES 2011-327 (2011); Ingels SJ, Dalton B, *High School Longitudinal Study of 2009 (HSLS:09) First Follow-up: A First Look at Fall 2009 Ninth-Graders in 2012*, NCES 2014-360 (2013). See appendix table 1-6.

Science and Engineering Indicators 2016

The HSLS:09 assessed two proficiency levels that ninth graders were not expected to reach but that at least some eleventh graders students were expected to attain (Ingels and Dalton 2013):

- Level 6: The student understands quadratic functions and the relationship between roots and the discriminant and can solve quadratic equations and inequalities.
- Level 7: The student understands exponential and log functions, including geometric sequences, and can identify inverses of log and exponential functions and when geometric sequences converge.

In 2012, approximately 5% of students were proficient at level 6, and approximately 2% were proficient at level 7 (Figure 1-6; Appendix Table 1-6). These numbers were substantially higher for Asian or Pacific Islander students than for any other group: 17% and 8%, respectively, more than triple the average (Appendix Table 1-6). Approximately 6% of male students and 5% of female students were proficient at level 6, a small but statistically significant difference. Student SES, parental education, race or ethnicity, and school type all influenced student scores. The patterns were broadly similar for level-7 proficiency.

International Comparisons of Mathematics and Science Performance

Governments are increasingly viewing their population's education levels and performance as national resources and are assessing their education status in a broader international context. The Organisation for Economic Co-operation and Development (OECD) has conducted a triennial Program for International Student Assessment (PISA) study since 2000 that allows comparisons of mathematics and science performance of 15-year-olds in the United States with that of their peers in other nations.[i] In addition to analyzing students' average performance among countries and trends over time, and new to this edition of *Science and Engineering Indicators*, this section examines variations in students' scores in different countries—that is, how tightly students' scores in any country cluster around that country's mean score.

Science and Engineering Indicators 2014 examined data from another international assessment, the Trends in International Mathematics and Sciences Study (TIMSS) (NSB 2014). TIMSS and PISA are different in design and goals and do not allow direct side-by-side comparison. The present analysis presents new PISA data from 2012 and looks at trends since 2003.

Principal differences between TIMSS and PISA are the following:[ii]

- **Grade level and scope.** TIMSS conducts mathematics and science assessments of students in grades 4 and 8. PISA, on the other hand, assesses the mathematics, science, and reading performance of 15-year-old students.[iii]
- **Knowledge and skills versus application of knowledge.** TIMSS assessments are designed to measure students' knowledge in the mathematics and science curricula of participating countries. PISA assessments are designed to measure students' ability to apply mathematics and science knowledge to real-world applications.
- **Country participation.** Although some of the same countries participate in both TIMSS and PISA, many countries participate in only one or the other.

PISA's focus is on the application of school knowledge to real-life situations. For example, students may be asked to estimate an area, identify the best price for a product, or interpret statistics in a news report (see sidebar, Sample Items from the Program for International Student Assessment Mathematics and Science Assessments).

Trends in Mathematics and Science Knowledge among 15-Year-Old Students in the United States

Figure 1-7 shows the average mathematics and science literacy scores for 15-year-old students in the United States between 2003 and 2012.[iv] Students in the United States had an average mathematics literacy score of 483 in 2003, 474 in 2006, 487 in 2009, and 481 in 2012. The average science literacy scores for U.S. students were 489 in 2006, 502 in 2009, and 497 in 2012. The average mathematics literacy scores for male students and female students did not change significantly from 2003 to 2012, nor did the science literacy scores change significantly from 2006 to 2012 (Table 1-3).

---

[i] OECD is an intergovernmental organization with membership of 34 advanced economies and 6 partner nations.

[ii] See the TIMMS website (https://nces.ed.gov/TIMSS/faq.asp?FAQType=8).

[iii] Schools in each country are randomly selected by the international contractor for participation in PISA. At these schools, the test is given to students who are between age 15 years 3 months and age 16 years 2 months at the time of the test, rather than to students in a specific year of school. This average age of 15 was chosen because at

this age young people in most OECD countries are nearing the end of compulsory education (http://www.oecd.org/pisa/aboutpisa/pisafaq.htm).

[iv]The PISA mathematics assessment was also conducted in 2000 but, because the framework for the mathematics assessment was revised in 2003, it is not appropriate to compare results from the 2000 assessment to subsequent PISA mathematics assessments. Similarly, the framework for the PISA science assessment was changed in 2000 and in 2003, preventing comparisons of results in either 2000 or 2003 with science literacy scores from subsequent years.

Sample Items from the Program for International Student Assessment Mathematics and Science Assessments

Sample Items from the 2012 Program for International Student Assessment (PISA) Mathematics Assessment

1. *Peter's bicycle has a wheel circumference of 96 cm (or 0.96 m). It is a three-speed bicycle with a low, a middle, and a high gear. The gear ratios of Peter's bicycle are:*

   Low 3:1 Middle 6:5 High 1:2

   How many pedal turns would Peter take to travel 960 m in middle gear? Show your work.
   NOTE: A gear ratio of 3:1 means 3 complete pedal turns yields 1 complete wheel turn.

   Correct answer: 1,200 pedal turns, with a fully correct method.

3. *One advantage of using a kite sail is that it flies at a height of 150 m. There, the wind speed is approximately 25% higher than down on the deck of the ship. At what approximate speed does the wind blow into a kite sail when a wind speed of 24 km/h is measured on the deck of the ship?*
   a. *6 km/h*
   b. *18 km/h*
   c. *25 km/h*
   d. *30 km/h*
   e. *49 km/h*

   Correct answer: D

Sample Items from the 2012 PISA Science Assessment

1. *Fevers that are difficult to cure are still a problem in hospitals. Many routine measures serve to control this problem. Among those measures are washing sheets at high temperatures.*

   Explain why high temperature (while washing sheets) helps to reduce the risk that patients will contract a fever.

   Correct answer: Answers that refer to the killing or removal of bacteria, microorganisms, germs, or viruses, or to the sterilization of the sheets.

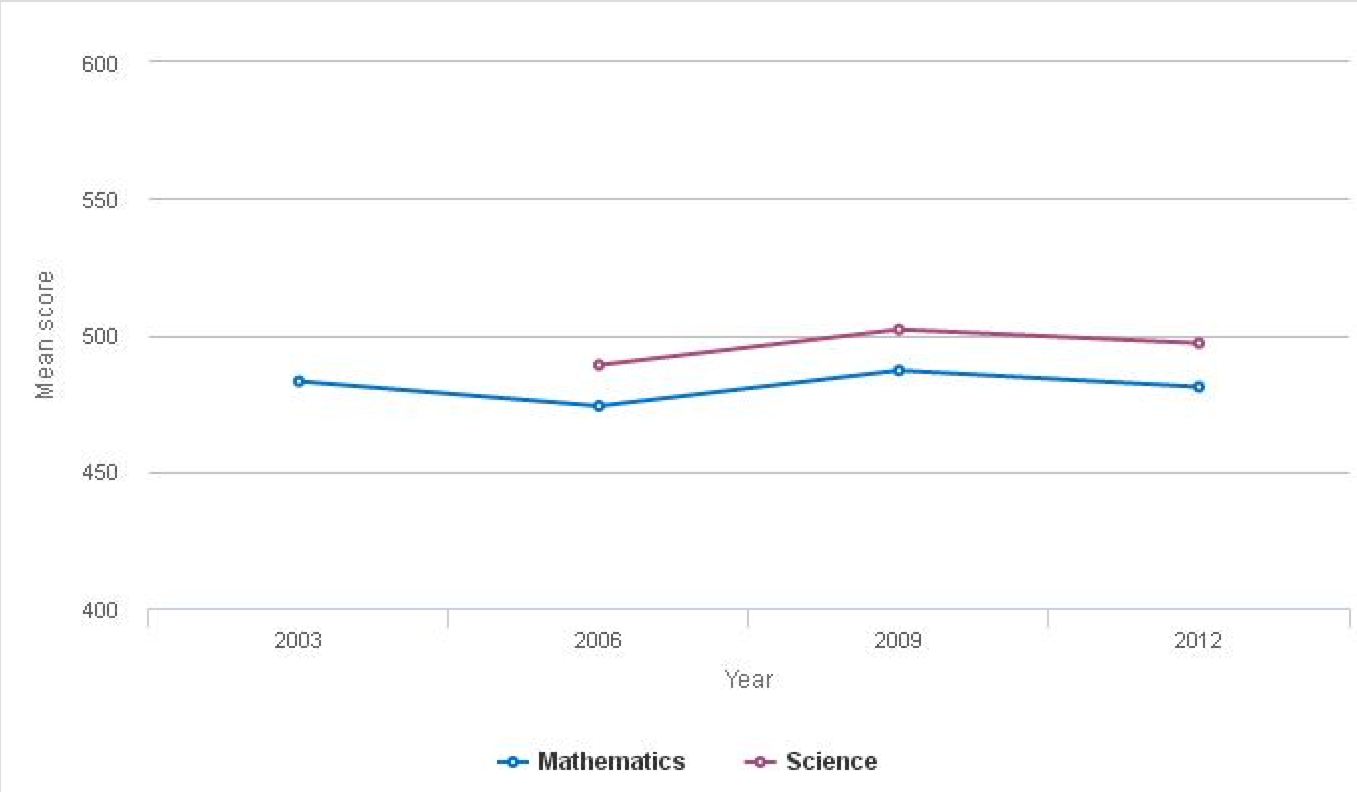
3. *The temperature in the Grand Canyon ranges from below 0 degrees C to over 40 degrees C. Although it is a desert area, cracks in the rocks sometimes contain water. How do these temperature changes and the water in rock cracks help to speed up the breakdown of rocks?*
    a. *Freezing water dissolves warm rocks.*
    b. *Water cements rocks together.*
    c. *Ice smooths the surface of rocks.*
    d. *Freezing water expands in the rock cracks.*

   Correct answer: D. Freezing water expands rock cracks.

Additional sample questions: http://nces.ed.gov/surveys/pisa/pdf/items_math2012.pdf (for mathematics) and http://nces.ed.gov/surveys/pisa/pdf/items_science.pdf (for science).

Figure 1-7

Mean mathematics and science literacy assessment scores of 15-year-old students in the United States: 2003–12



NA = not available; science literacy assessment was not administered in 2003.

NOTE: The mathematics and science literacy assessment scores range from 0 to 1,000.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2014) of the Program for International Student Assessment 2003, 2006, 2009, and 2012 mathematics and science literacy assessments, National Center for Education Statistics.

Science and Engineering Indicators 2016

Table 1-3 Mean mathematics and science literacy assessment scores of 15-year-old students in the United States, by sex: 2003–12

	Mathematics		Science	
Year	Male	Female	Male	Female
2003	486	480	NA	NA
2006	479	470	489	489
2009	497	477	509	495
2012	484	479	497	498

NA = not available.

NOTES:	The mathematics and science literacy assessment scores range from 0 to 1,000. Science literacy assessment was not administered in 2003.
SOURCE:	National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2014) of the Program for International Student Assessment 2003, 2006, 2009, and 2012 mathematics and science literacy assessments, National Center for Education Statistics.
	Science and Engineering Indicators 2016

Mathematics Literacy among U.S. 15-Year-Olds

U.S. students' average mathematics score of 481 in 2012 was lower than the average score for all developed countries, 501. It was also lower than the scores of students from two-thirds of all developed countries (Appendix Table 1-7). Among developed countries, students from Singapore had the highest literacy score at 574 (Table 1-4). Other developed countries with average scores that were significantly higher than that of U.S. students included Switzerland (531), Finland (519), Germany (514), Slovenia (501), and Iceland (493). The U.S. students' average mathematics score was also lower than that of two developing countries, Vietnam (511) and the Russian Federation (482). Overall, U.S. students performed relatively well on PISA items that required only lower-level skills—reading and simple handling of data directly from tables and diagrams, handling easily manageable formulas—but they struggled with tasks involving creating, using, and interpreting models of real-world situations and using mathematical reasoning (OECD 2015).

Table 1-4 **Mean mathematics literacy assessment scores of 15-year-old students in developed countries, by country: 2012**

Grouping and country	Score
Score higher than United States' score of 481	
Singapore	574
South Korea	554
Japan	536
Switzerland	531
Netherlands	523
Estonia	521
Finland	519
Canada	518
Poland	518
Belgium	515
Germany	514
Austria	506
Australia	504
Ireland	502
Slovenia	501
Denmark	500
New Zealand	500

Grouping and country	Score
Czech Republic	499
France	495
United Kingdom	494
Iceland	493
Latvia	491
Luxembourg	490
Score not statistically different from United States' score of 481	
Norway	489
Portugal	487
Italy	485
Spain	484
Slovakia	482
United States	481
Sweden	478
Score lower than United States' score of 481	
Israel	467
Greece	453

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2014) of the Program for International Student Assessment 2012 mathematics literacy assessment, National Center for Education Statistics. See appendix table 1-7.

Science and Engineering Indicators 2016

Science Literacy among U.S. 15-Year-Olds

The average science literacy score for U.S. students in 2012 was 497, lower than the average science score of 511 for all developed countries (Appendix Table 1-8). Among developed countries, Singapore had the highest score at 552 (Table 1-5). Other developed countries with science literacy scores that were significantly higher than that of U.S. students included Japan (547), South Korea (538), Germany (524), and the United Kingdom (514).

Table 1-5 **Mean science literacy assessment scores of 15-year-old students in developed countries, by country: 2012**

Grouping and country	Score
Score higher than United States' score of 497	
Singapore	552
Japan	547
Finland	545
Estonia	541

Grouping and country	Score
South Korea	538
Poland	526
Canada	525
Germany	524
Ireland	522
Netherlands	522
Australia	522
New Zealand	516
Switzerland	515
Slovenia	514
United Kingdom	514
Czech Republic	508
Score not statistically different from United States' score of 497	
Austria	506
Belgium	505
Latvia	502
France	499
Denmark	498
United States	497
Spain	496
Norway	495
Italy	494
Luxembourg	491
Portugal	489
Score lower than United States' score of 497	
Sweden	485
Iceland	478
Slovakia	471
Israel	470
Greece	467

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2014) of the Program for International Student Assessment 2012 science literacy assessment, National Center for Education Statistics. See appendix table 1-8.

Science and Engineering Indicators 2016

Variability in Mathematics and Science Achievement across Countries

Chapter 1. **Elementary and Secondary Mathematics and Science Education**

The data in this chapter primarily include mean student achievement scores in mathematics and science in the United States and other countries. The variability of student scores on a mathematics or a science test may provide additional insights into the well-being of K–12 STEM education in the United States. For instance, if the United States has higher overall variability in achievement than other countries, this may indicate that educational outcomes are more unequal in the United States. Also, the percentage of U.S. students scoring at very high values relative to those of other countries may provide insights on how well the United States fares in preparing students to be STEM innovators. The percentage scoring at very low values may indicate education system shortcomings.

This section will present information on overall variability, measured as the average distance of students' scores from the mean of those scores. This is the *mean deviation*. A mean deviation of 75, to take a value typical of developed countries, indicates that, on average, students are 75 points from the mean in either direction. For a country with a bell-shaped distribution of student achievement, which is approximately the case for many countries, a 75-point mean deviation would also mean that 90% of students would fall within 184 points from the mean, in both directions. This section will also examine how different countries compare in the highest and lowest percentiles of achievement. All data in this section are from the 2012 PISA.

The United States is quite typical, among 32 developed countries, in terms of overall variability and has lower variability than several Nordic countries noted for their egalitarianism. With a mean deviation of 76 for science achievement, the United States is very near the median score of 77 for the developed countries in the data (Table 1-6).[v] The United States has a lower mean deviation for science achievement than Norway, Sweden, and Iceland.[vi] In addition, these countries do not have a higher *average* for science achievement than the United States. On the other hand, South Korea and Estonia have higher average scores than the United States and also have mean deviations about 10 points or more below that of the United States.

---

[v]PISA contains data on a few country regions such as particular U.S. states, the Perm region of Russia, and Chinese cities. These are not included in analyses in the text of these sections, in which only whole countries are considered. Developed and developing status are defined by the International Monetary Fund's classification of countries into advanced and emerging economies (https://www.imf.org/external/pubs/cat/longres.aspx?sk=24628.0).

[vi]All scores and comparisons in this section were calculated in accordance with the formulae presented in the *PISA Data Analysis Manual: SAS®* (OECD 2009).

Table 1-6 **Mean deviation of science literacy assessment scores of 15-year-old students in developed countries, by country: 2012**

Grouping and country	Score
Mean deviation higher than United States' mean deviation of 76	
Israel	87
New Zealand	85
Singapore	85
Luxembourg	84
Belgium	81

Grouping and country	Score
Slovakia	81
Australia	81
France	80
United Kingdom	80
Sweden	80
Norway	80
Iceland	80
Mean deviation not statistically different from United States' mean deviation of 76	
Netherlands	77
Germany	77
Japan	76
United States	76
Austria	75
Italy	75
Denmark	74
Finland	74
Slovenia	73
Switzerland	73
Ireland	73
Canada	72
Mean deviation lower than United States' mean deviation of 76	
Czech Republic	72
Portugal	71
Greece	71
Poland	69
Spain	69
South Korea	65
Estonia	64
Latvia	63

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2014) of the Program for International Student Assessment 2012 science literacy assessment, National Center for Education Statistics. See appendix table 1-8.

Science and Engineering Indicators 2016

The lower mean deviation for the United States in contrast to the Nordic countries, despite the generally recognized greater ethnic diversity of the United States, suggests that mean deviation does not merely reflect diversity. If mean deviation is a summary of inequalities from all sources that affect achievement, the poorer mean deviations of Nordic countries with respect to science achievement scores might reflect sources of inequality such as less integrated immigrant populations or educational tracks.

The United States produces more students at or below the 10% mark for all developed countries in science. Almost 12% of American students are at or below the science achievement score defining the bottom 10% of students for all developed countries (Appendix Table 1-8). Compared with all developed countries, 17% more U.S. students are at or below the 10% threshold. This takes into account the size of the United States population. Additionally, the United States produces fewer students above the scores that define the 90th, 95th, and 99th percentiles across all developed countries. The United States has about 23% fewer students in each of these high-score groups.

Finland is at times cited as an exemplary educational system. With variability for science achievement that is practically identical to that of the United States, Finland's advantage is in higher average science achievement. Another Baltic country that stands out more sharply than Finland in the PISA data is Estonia. Estonia shows that it is possible both to have a better average science score than the United States and to maintain lower variability and better percentile values (Appendix Table 1-8). Mean deviations sharply lower than those of the United States could be due to policy, sociostructural, or cultural reasons that may or may not be duplicable in the United States.

The 27 developing countries in the PISA data have, typically, lower variation in achievement than in developed countries. Because these countries select themselves for inclusion in PISA, it is not possible to generalize to all developing countries. Nevertheless, these countries can serve as a contrast to developed countries. Half of these countries have a mean deviation for science achievement of 64.7 or lower. In short, these mean deviations for self-selected developing countries are shifted down by about 10 points from those of developed countries. These developing countries also, however, have a lower median value of average science scores, 438 (versus 525 for developed countries).

The 2012 PISA survey also provides data regarding mathematics achievement. The findings are broadly similar to those for science achievement. With a mean deviation of 73 for mathematics achievement, the United States has the tenth-largest variability of 32 developed countries—moderately near the median score of 78 (Table 1-7). The United States has about the same variability for mathematics achievement as Norway, Sweden, and Iceland. Additionally, differences among these countries in mean scores are small. On the other hand, a number of countries do somewhat better than the United States both in terms of mean and mean deviation in mathematics, particularly Estonia, Latvia, Denmark, and Finland. The first two of these countries also had appreciably lower mean deviations for science achievement.

Table 1-7 **Mean deviation of mathematics literacy assessment scores of 15-year-old students in developed countries, by country: 2012**

Grouping and country	Score
Mean deviation higher than United States' mean deviation of 73	
Singapore	86
Israel	85
Belgium	83
Slovakia	81
New Zealand	81
South Korea	80

Grouping and country	Score
France	79
Germany	78
Luxembourg	78
Australia	78
Czech Republic	77
Portugal	77
United Kingdom	76
Switzerland	76
Mean deviation not statistically different from United States' mean deviation of 73	
Austria	75
Japan	75
Netherlands	75
Slovenia	75
Italy	75
Sweden	74
Iceland	74
Poland	73
United States	73
Norway	73
Canada	72
Spain	71
Greece	71
Mean deviation lower than United States' deviation of 73	
Finland	68
Ireland	68
Denmark	66
Latvia	66
Estonia	65

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2014) of the Program for International Student Assessment 2012 mathematics literacy assessment, National Center for Education Statistics. See appendix table 1-7.

Science and Engineering Indicators 2016

The United States falls particularly short with respect to students in the highest percentiles of mathematics achievement. If the United States was doing as well as other developed countries, then 1% of U.S. students would be at or above the score that defines the 99th percentile of students across all developed countries. Instead, only about 0.4% of U.S. students have a score at or above that 99th percentile score for developed countries, with the result that the United States has 61% fewer students in this group than the average for developed countries (Appendix Table 1-7). Similarly, the United States has 42% and 45% fewer students compared with all developed countries above the scores that define, respectively, the 90th and 95th percentiles of students across all developed countries. In addition, the United States has values for mathematics achievement in two of the lower ranges of percentiles that are worse than for all developed countries: the United States has 24% more students below the international 10% score, and it has 18% more students below the international 5% score.

As with science scores, the mean deviations for developing countries are shifted down about 10 points from those of developed countries. The average of mean mathematics scores for developing countries, however, is 439, in contrast with 520 for developed countries.

High School Coursetaking in Mathematics and Science

To understand students' achievement in mathematics or science, it helps to understand what courses they have taken. This section examines high school students' participation in mathematics and science courses using data from HSLS:09, the College Board's AP program, and data collected from OCR. HSLS:09 data describe the breadth of mathematics and science coursetaking from the ninth through eleventh grades, as reported by students. AP data describe students' success in mastering the material taught in college-level mathematics and science courses while in high school as measured by AP test scores. OCR data provide enrollments in high school science and mathematics courses nationwide by sex, race, and ethnicity. The main findings in this section are that the United States is making progress in increasing advanced coursetaking, though the overall percentage of students taking mathematics and science AP tests remains small, and wide gaps persist in advanced coursetaking among students from different socioeconomic backgrounds.

Eleventh Grade Mathematics and Science Coursetaking

In addition to the algebra achievement data discussed above, HSLS:09 provides detailed data about high school students' coursetaking in mathematics and science and the high school and personal factors that lead students into and out of STEM fields of study and related careers.[i] Although subsequent follow-ups include collection and coding of high school transcripts in 2013, as well as a second follow-up survey to be conducted in 2016, the coursetaking data reported here are drawn from students' responses to questions about the courses in which they were enrolled in the 2008–09 and 2011–12 academic years.[ii] Future transcript data will examine directly which courses students attempted and passed.

Science and Engineering Indicators 2014 (NSB 2014) presented data about the mathematics and science courses that ninth graders enrolled in and about variations in their coursetaking by such factors as race and ethnicity, parental education level, and SES. Algebra 1 and biology 1 were the most common courses for ninth graders. Students who had a parent with a master's degree or higher were more likely to report enrollment in a mathematics course above algebra 1, and students in the lowest SES category were more likely to report no enrollment in science or mathematics. This section examines the mathematics and science coursetaking patterns of these students when most of them were in the spring of their eleventh grade year.

---

[i] NCES established the Secondary Longitudinal Studies Program (SLSP) to study the educational, vocational, and personal development of young people beginning with their high school years and following them over time into adult roles and responsibilities. Thus far, the SLSP consists of five major studies: the National Longitudinal Study of the High School Class of 1972 (NLS:72); the High School and Beyond (HS&B) survey; the National Education Longitudinal Study of 1988 (NELS:88); the Education Longitudinal Study of 2002 (ELS:2002); and the High School Longitudinal Study of 2009 (HSLS:09). More information about each of these studies is available at http://nces.ed.gov/surveys/slsp.

[ii] Additional follow-ups by NCES are currently planned to at least age 26.

Mathematics Coursetaking

Completing algebra 2 (or an equivalent course) is a high school graduation requirement under the "college- and career-ready" graduation requirements that 25 states have adopted (Achieve Inc. 2013). As of 2012, 69% of current eleventh graders (who were ninth graders in 2009) were enrolled in algebra 2 or a more advanced mathematics course (Table 1-8).[iii] Among the remaining students, 12% were taking geometry 1, 8% were taking algebra 1 or more basic mathematics, and 11% were not enrolled in any mathematics course. Substantial demographic disparities exist: 56% of students from the bottom SES quintile were taking algebra 2 or higher, compared to 83% of students from the top SES quintile (Appendix Table 1-9). Nonetheless, substantial percentages of students were enrolled in algebra 2 or higher across most demographic categories: 51% of students whose parents never completed high school, 54% of those who entered high school expecting to complete high school or less, 45% of students in the lowest quintile of prior mathematics achievement,[iv] and 56% of students from the bottom SES quintile. Across racial or ethnic groups, the percentage of students who took algebra 2 or higher ranged from 62% among Hispanic students to 86% among Asian or Pacific Islander students.

[iii] Population statistics derived from HSLS:09 are derived using the appropriate sample weights.

[iv] The prior mathematics achievement quintile score is a norm-referenced measure of achievement. The quintile score divides the weighted (population estimate) achievement distributions into five equal groups, based on mathematics score. See chapter 2 of the *HSLS:09 Base-Year Data File Documentation* for more information on the derivation of the mathematics quintile score (Ingels et al. 2011).

Table 1-8 **Highest-level mathematics course in which students in grade 11 enrolled, by student and family characteristics: 2012**

(Percentage distribution)

Student and family characteristic	No mathematics	Basic math and algebra 1	Geometry 1	Algebra 2	Trigonometry, calculus, and other advanced math[a]
All students	11.3	7.7	12.1	33.5	35.4
Sex					
Male	11.5	8.4	13.5	32.7	34.0
Female	11.2	7.0	10.7	34.4	36.8
Race or ethnicity					
White	10.6	7.2	10.1	32.8	39.3
Black	15.7	8.2	11.3	35.1	29.7
Hispanic[b]	11.0	8.5	18.2	34.3	27.9
Asian	5.9	3.1	5.3	22.4	63.5
Other	11.9	9.5	12.8	38.4	27.6
Parents' highest education[c]					
Less than high school	15.1	16.5	17.8	26.6	24.0
High school diploma or equivalent	14.5	10.1	14.7	34.3	26.3
Associate's degree	12.1	8.7	16.5	34.6	28.0

Student and family characteristic	No mathematics	Basic math and algebra 1	Geometry 1	Algebra 2	Trigonometry, calculus, and other advanced math[a]
Bachelor's degree	10.6	6.7	12.4	37.1	33.2
Master's degree or higher	7.9	4.6	6.5	27.8	53.1
Highest mathematics course in grade 9					
No mathematics	20.0	10.8	12.9	29.6	26.8
Basic math/pre-algebra	13.4	16.9	27.6	25.4	16.7
Algebra 1	9.9	7.2	14.5	49.3	19.0
Above algebra 1	10.0	4.7	2.2	10.2	73.0
Students' educational expectations in grade 9					
High school or less	14.0	12.6	19.8	35.7	18.0
Some college	13.7	11.6	14.8	38.0	21.8
Bachelor's degree	9.8	6.6	10.3	36.2	37.0
Graduate/professional degree	10.1	4.9	7.2	30.6	47.1
Don't know	11.9	9.3	16.6	36.3	26.1
Control of school in grade 12					
Public	11.6	7.7	12.5	33.6	34.6
Private	2.5	3.5	5.6	36.1	52.2
Socioeconomic status in grade 12[d]					
Lowest fifth	15.7	12.0	16.3	32.8	23.3
Middle three-fifths	11.3	7.8	12.7	36.0	32.3
Highest fifth	7.4	3.4	6.5	27.2	55.6

[a] Includes probability and statistics, trigonometry and pre-calculus, analytic geometry and calculus, and other advanced math.

[b] Hispanic may be any race. Asian, black or African American, white, and other races refer to individuals who are not of Hispanic origin.

[c] The highest level of education achieved by either parent.

[d] Socioeconomic status (SES) is a composite variable derived from parental education level, parental occupation, and family income. The quintile measure divides the SES distribution into five equal quintile groups. Quintile 1 corresponds to the lowest one-fifth of the population, and quintile 5 corresponds to the highest. For this report, the middle three quintiles are combined into one category.

NOTE: Percentages may not add to total because of rounding.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2014) of High School Longitudinal Study of 2009 (HSLS:09), National Center for Education Statistics. See appendix table 1-9.

The HSLS:09 data show that the proportion of students reporting enrollment in courses above algebra 2 varies by demographic characteristics. Overall, 35% of all students took courses beyond algebra 2. The proportion of Asian or Pacific Islander students (64%) reporting enrollment in such courses, however, is more than twice as large as the proportion of black (30%), Hispanic (28%), or other nonwhite and not Hispanic (28%) students reporting enrollment. Additionally, the proportion who took such courses was more than twice as high for students whose highest educated parent had a master's degree or higher (53%) than for those whose parents had a high school diploma (26%) or did not finish high school (24%). Students from the highest SES quintile (56%) took these courses at twice the rate of students from the lowest SES quintile (23%).

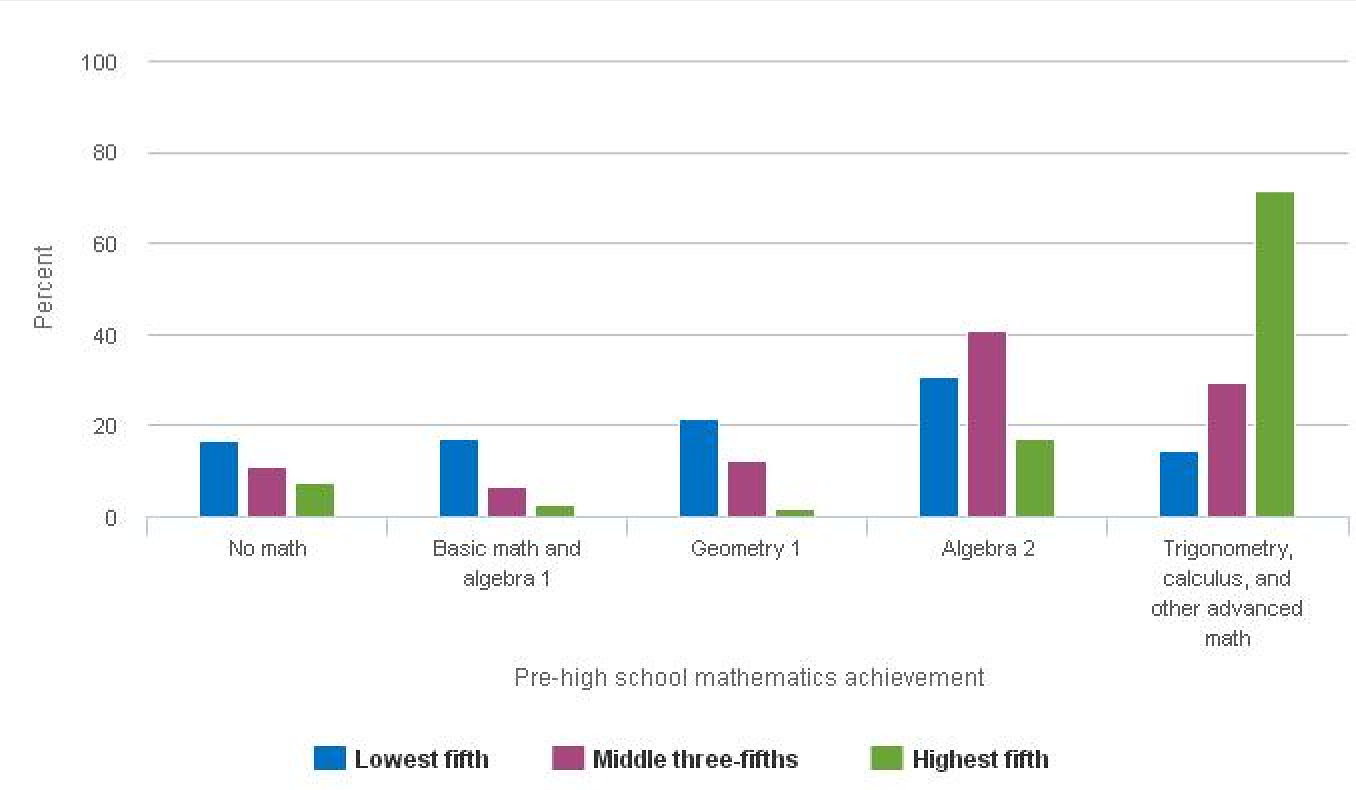
Data from HSLS:09 confirm that prior academic performance strongly predicts later coursetaking (Conger, Long, and Iatarola 2009; Zietz and Joshi 2005). Seventy-one percent of students in the top quintile of prior mathematics achievement (determined from a measure of students' mathematics achievement as they entered ninth grade in fall 2009) took trigonometry, calculus, and other advanced mathematics courses, compared with 30% of students in the middle three quintiles and 15% in the bottom quintile (Figure 1-8). Similarly, 73% of students who had taken a class above algebra 1 in their freshman year had moved beyond algebra 2 by their junior year, whereas only 19% of 2009 freshman who had taken algebra 1 had done so.[v]

---

[v] Freshman year coursetaking data come from *Science and Engineering Indicators 2014* (NSB 2014). Overall, 10% of freshmen were not enrolled in a mathematics course, 9% were enrolled in basic mathematics or pre-algebra, 52% were enrolled in algebra 1, and 29% were enrolled in a more advanced course.

Figure 1-8

Highest-level mathematics course enrollment of students in grade 11, by pre-high school mathematics achievement: 2012



NOTE: Other advanced math includes probability and statistics, trigonometry and pre-calculus, analytic geometry and calculus, and other advanced math.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2014) of High School Longitudinal Study of 2009 (HSLS:09), National Center for Education Statistics. See appendix table 1-9.

Science and Engineering Indicators 2016

Science Coursetaking

Biology 1 was the most prevalent science course among ninth graders in 2009, with 39% of students enrolled (NSB 2014). Three years later, in 2012, 41% of this cohort (most of whom were in their second semester of eleventh grade) had enrolled in the other level-1 science courses, chemistry 1 or physics 1 (Table 1-9). Moreover, across demographic groups defined by sex and by race or ethnicity, students enrolled in other level-1 courses at comparable rates: 40% of male students and 42% of female students; 43% of Asian or Pacific Islander students, 42% of white students, 41% of black students, and 40% of Hispanic students. Larger differences were observed across the spectra of parental education and SES: 32% of students whose parents had less than a high school education, for example, enrolled in chemistry 1 or physics 1, compared to 43% of students whose highest-educated parent had a bachelor's degree. Similarly, 35% of students from the bottom SES quintile enrolled in these courses, compared with 46% of students from the top quintile.

Table 1-9 **Highest-level science course enrollment of students in grade 11, by student and family characteristics: 2012**

(Percentage distribution)

Student and family characteristic	No science	General, basic, earth /environmental, physical science	Biology 1	Chemistry 1 or physics 1	Advanced science[a]
All students	19.9	8.6	10.6	40.8	20.1
Sex					
Male	21.1	9.9	11.3	39.6	18.2
Female	18.7	7.3	9.9	42.1	22.0
Race or ethnicity					
White	18.4	8.7	9.4	41.9	21.7
Black	23.7	9.2	11.6	40.8	14.8
Hispanic[b]	22.2	8.2	12.7	39.8	17.1
Asian	8.6	3.8	7.1	43.2	37.3
Other	22.2	10.9	12.5	36.0	18.5
Parents' highest education[c]					
Less than high school	32.6	10.1	11.1	31.5	14.7
High school diploma or equivalent	20.8	10.6	13.2	39.3	16.2
Associate's degree	26.6	10.8	14.0	33.6	15.1
Bachelor's degree	18.8	10.2	10.0	43.3	17.6
Master's degree or higher	12.8	6.7	6.9	44.8	28.9
Highest science course in grade 9					
No science	33.0	10.1	13.1	29.8	14.0
General science	19.6	9.5	18.7	37.7	14.5

Student and family characteristic	No science	General, basic, earth /environmental, physical science	Biology 1	Chemistry 1 or physics 1	Advanced science[a]
Earth/environmental/physical science	18.1	9.4	9.7	46.2	16.7
Biology 1	15.5	8.0	8.2	43.0	25.2
Above biology 1	16.7	3.6	17.5	36.5	25.7
Students' educational expectations in grade 9					
High school or less	29.1	12.0	17.1	28.6	13.3
Some college	22.7	12.8	11.1	38.8	14.6
Bachelor’s degree	17.9	7.2	8.7	47.2	19.0
Graduate/professional degree	15.9	6.1	7.7	44.0	26.3
Don't know	21.6	11.1	13.1	38.8	15.4
Control of school in grade 12					
Public	20.1	8.8	10.8	40.4	19.8
Private	7.5	4.5	6.3	55.2	26.5
Socioeconomic status in grade 12[d]					
Lowest fifth	25.9	9.7	14.6	34.6	15.1
Middle three-fifths	20.5	9.3	10.8	41.1	18.3
Highest fifth	12.8	5.6	6.4	45.6	29.7

[a] Includes biology 2, chemistry 2, physics 2, and other advanced science.

[b] Hispanic may be any race. Asian, black or African American, white, and other races refer to individuals who are not of Hispanic origin.

[c] The highest level of education achieved by either parent.

[d] Socioeconomic status (SES) is a composite variable derived from parental education level, parental occupation, and family income. The quintile measure divides the SES distribution into five equal quintile groups. Quintile 1 corresponds to the lowest one-fifth of the population, and quintile 5 corresponds to the highest. For this report, the middle three quintiles are combined into one category.

NOTE: Percentages may not add to total because of rounding.

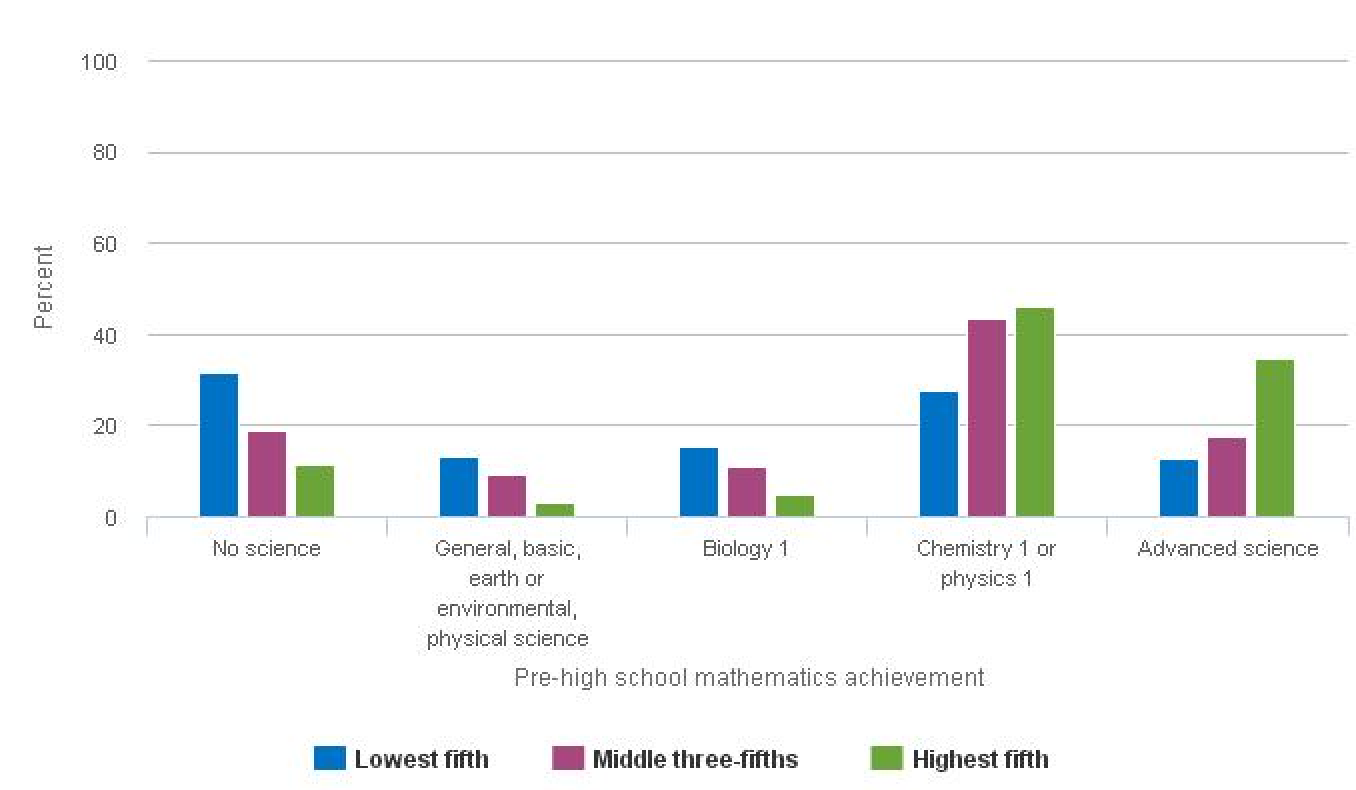
SOURCE:	National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2014) of High School Longitudinal Study of 2009 (HSLS:09), National Center for Education Statistics. See appendix table 1-10. *Science and Engineering Indicators 2016*

The pattern in level-1 chemistry or physics coursetaking varied appreciably by prior mathematics achievement,[vi] with 28% of students from the bottom achievement quintile enrolling in these classes versus 46% of those in the top achievement quintile (Figure 1-9). There were also large differences by educational expectations, with 29% enrollment in chemistry 1 or physics 1 among students anticipating a high school diploma or less, compared with 47% of students anticipating a bachelor's degree and 44% of students anticipating a graduate or professional degree (Table 1-9).

[vi] Prior science achievement was not measured in HSLS:09.

Figure 1-9

Highest-level science course enrollment of students in grade 11, by pre-high school mathematics achievement: 2012



NOTE: Advanced science includes biology 2, chemistry 2, physics 2, and other advanced science.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2014) of High School Longitudinal Study of 2009 (HSLS:09), National Center for Education Statistics. See appendix table 1-10.

Science and Engineering Indicators 2016

As with mathematics, taking advanced science courses in high school allows students to move through college science curricula quickly. For example, advanced science coursetaking in high school has been associated with better performance in introductory college biology, a prerequisite for more advanced study in biology and health-related fields (Loehr et al. 2012). Similarly, enrollment and performance in advanced physics and calculus courses during high school are also positively associated with performance in college physics and calculus courses (Tyson 2011).

Disparities in advanced science coursetaking, therefore, have consequences, and the HSLS:09 data reveal that, as with mathematics, the percentage of students taking more advanced science courses (i.e., level-2 sciences and similar) varied with some demographic characteristics. Overall, 20% of students took advanced science courses in spring 2012, with young women slightly more likely than young men to do so (22% versus 18%) (Table 1-9). But whereas 15% and 17% of black and Hispanic students took these courses, respectively, more than twice as many Asian or Pacific Islander students did (37%). The ratio was similar across other demographic categories as well:

- Fifteen percent of students whose most-educated parent had less than a high school education took advanced science, compared with 29% of those whose most-educated parent had at least a master's degree.

- Thirteen percent of students in the lowest quintile of mathematics achievement took advanced science, compared with 35% of those in the highest achievement quintile (Appendix Table 1-10).
- Thirteen percent of students anticipating completing at most a high school education took advanced science, compared to 26% of those anticipating completing a graduate degree.
- Fifteen percent of students in the lowest SES quintile took advanced science, compared to 30% of those in the highest SES quintile.

Computer Science and Engineering Coursetaking

Computer science and coding skills are widely recognized as a valuable asset in the current and projected job market (Zinth 2015). The Bureau of Labor Statistics projects 37.6% growth from 2012 to 2022 in the computer systems design and related services industry—from 1,620,300 jobs in 2012 to a projected 2,229,000 jobs in 2022 (U.S. DOL/BLS 2013). The percentages of U.S. students taking computer science and engineering courses in high school are quite low, however, and vary by sex and other demographic characteristics. A recent survey of high school administrators indicates that most schools offer computer science, but most of these schools count computer science as an elective rather than a requirement, which may contribute to a low percentage of students taking such courses (CSTA 2014). To encourage districts to offer computer science courses—and to encourage students to complete these classes—14 states have amended high school graduation requirements either to allow or require computer science to fulfill math, science, or foreign language course requirements (Zinth 2015). Several states also have begun to require computer science courses to fulfill requirements for a specialized diploma or an endorsement to the standard high school diploma.

HSLS:09 data show that a quite small proportion of students take computer science or engineering courses, with 6% of second-semester eleventh graders taking computer science classes and 2% taking engineering classes in 2012 (Table 1-10). Male students were more likely to take both types of courses. About 3% of male students took engineering courses, compared with less than 1% of female students (Appendix Table 1-11). In computer science, it was 7% of male students, compared with 4% of female students. This gender disparity is also apparent in AP courses, with courses such as computer science A made up of 81% male students and just 19% of female students (Figure 1-10).

Table 1-10 **Engineering and computer/information science course enrollment of students in grade 11, by student and family characteristics: 2012**

(Percent)

Student and family characteristic	Engineering	Computer/ information science
All students	2.0	5.7
Sex		
Male	3.3	7.2
Female	0.7	4.2
Race or ethnicity		
White	2.1	5.5
Black	1.9	5.6
Hispanic[a]	1.6	6.2
Asian	1.9	6.9

Student and family characteristic	Engineering	Computer/ information science
Other	2.1	5.7
Parents' highest education[b]		
Less than high school	1.4	8.1
High school diploma or equivalent	1.2	7.7
Associate's degree	2.4	4.2
Bachelor's degree	1.5	4.7
Master's degree or higher	2.6	5.6
Highest mathematics course in grade 9		
No math	2.3	6.4
Basic math/pre-algebra	1.5	4.0
Algebra 1	1.7	5.5
Above algebra 1	2.4	6.4
Students' educational expectations in grade 9		
High school or less	1.9	5.3
Some college	1.8	4.6
Bachelor's degree	2.3	6.4
Graduate/professional degree	2.1	5.9
Don't know	1.7	5.7
Control of school in grade 12		
Public	2.1	5.8
Private	1.0	4.0
Socioeconomic status in grade 12[c]		
Lowest fifth	1.4	7.8
Middle three-fifths	2.1	5.1
Highest fifth	2.2	5.6

[a] Hispanic may be any race. Asian, black or African American, white, and other races refer to individuals who are not of Hispanic origin.

[b] The highest level of education achieved by either parent.

[c] Socioeconomic status (SES) is a composite variable derived from parental education level, parental occupation, and family income. The quintile measure divides the SES distribution into five equal quintile groups. Quintile 1 corresponds to the lowest one-fifth of the population, and quintile 5 corresponds to the highest. For this report, the middle three quintiles are combined into one category.

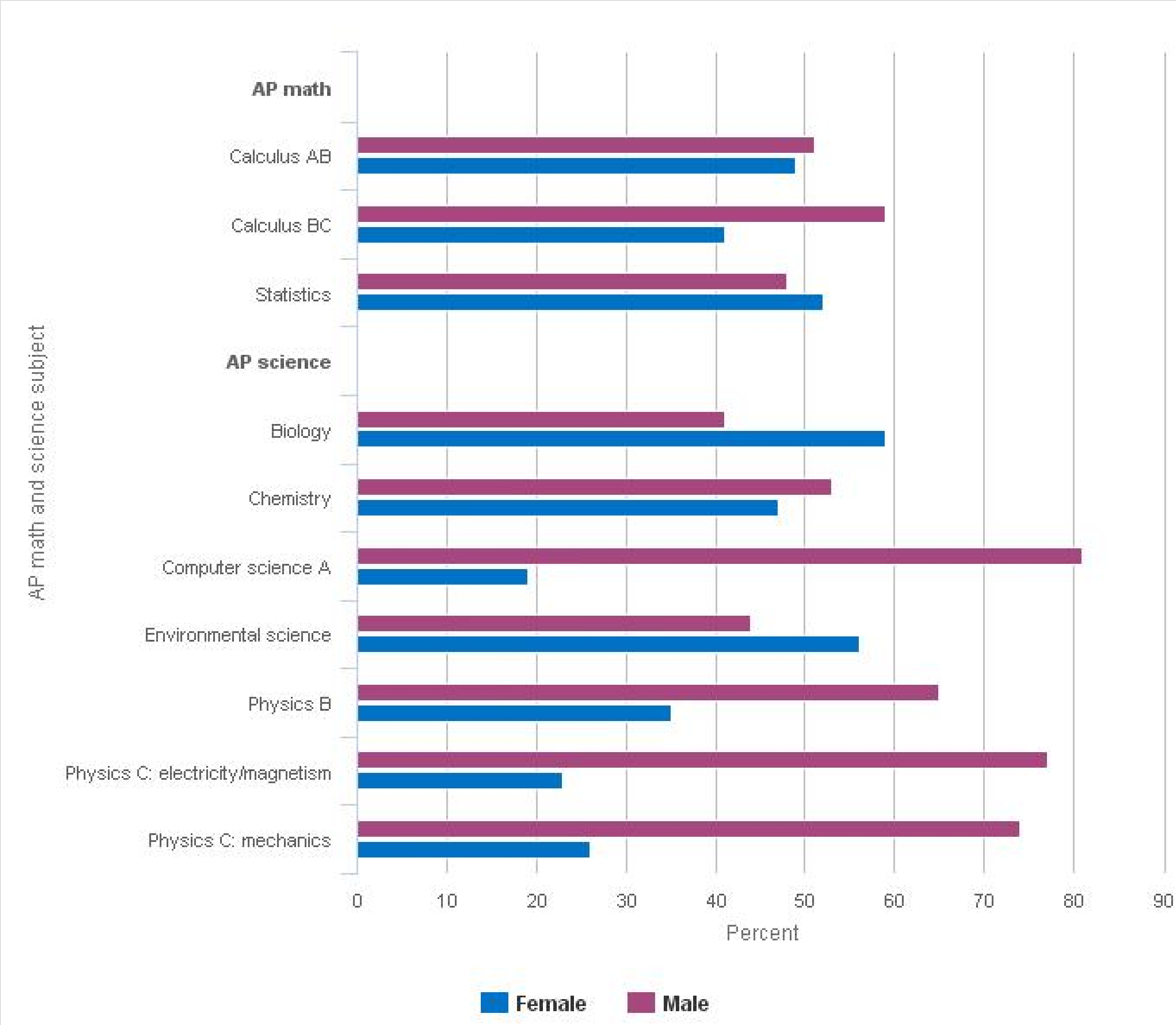
NOTE: Percentages may not add to total because of rounding.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2014) of High School Longitudinal Study of 2009 (HSLS:09), National Center for Education Statistics. See appendix table 1-11.

Science and Engineering Indicators 2016

Figure 1-10

Public school students in graduating class of 2013 who took AP exams in mathematics and science in high school, by sex



AP = Advanced Placement.

NOTES: The College Board reports AP results by graduating class rather than by calendar year. Results include exams taken by graduates throughout their high school career.

SOURCE: The College Board, *The 10th Annual AP® Report to the Nation—Subject Supplement.* Copyright © 2014, www.collegeboard.org. Reproduced with permission.

Science and Engineering Indicators 2016

Participation and Performance in the Advanced Placement Program

The AP program is one of the largest and most well-known programs offering high school students the opportunity to earn college credit. Other opportunities include the International Baccalaureate program, which also offers college credit for high school courses, and dual enrollment, where students enroll in college courses while still in high school (Thomas et al. 2013).

Administered by the College Board, a nonprofit organization, the AP program offers college-level courses in 34 different subjects in students' high schools, enabling students to earn credit toward both high school diplomas and college degrees simultaneously. The College Board also administers exams that test students' mastery of course material. Students who earn a passing score (3 or higher out of 5) on an AP exam may be eligible to earn college credits, placement into more advanced college courses, or both, depending on the policy of the postsecondary institution they attend.

AP Exam Taking and Performance among All Students

About one-third of 2013 high school graduates took an AP exam in any subject, and about one-fifth of all students passed the exam. Seventeen percent of students took an AP mathematics or science exam, and 10% passed (Table 1-11). Among mathematics and science exams, calculus AB has been the most popular, followed by biology; both remained so in 2013, when approximately 223,000 students took the calculus AB exam and 162,000 took the biology exam. Fewer students took more advanced exams (e.g., calculus BC, taken by about 78,000 students). Physics C: electricity and magnetism was the least popular exam among 2013 graduates, taken by approximately 14,000 students (Table 1-12).

Table 1-11 **Public school students who took or passed an AP exam as a proportion of overall student population, by subject: Graduating classes 2003, 2008, and 2013**

(Percent)

	Students who took an AP exam			Students who passed an AP exam[a]		
Subject	2003	2008	2013	2003	2008	2013
Any subject	18.9	25.2	33.2	12.2	15.4	20.1
Mathematics or science[b]	10.0	13.2	17.4	6.1	7.4	9.7

AP = Advanced Placement.

[a] Students scoring 3, 4, or 5 on a scale of 1–5 for an AP exam.

[b] Includes calculus AB, calculus BC, statistics, biology, chemistry, environmental science, computer science A, physics B, physics C: electricity/magnetism, and physics C: mechanics.

NOTES: The College Board reports AP results by graduating class rather than by calendar year. Results include exams taken by graduates throughout their high school career.

SOURCE: The College Board, *The 10th Annual AP® Report to the Nation—Subject Supplement*. Copyright © 2014, www.collegeboard.org. Reproduced with permission.

Science and Engineering Indicators 2016

Table 1-12 **Public school students who took or passed an AP exam in high school, by subject: Graduating classes 2003, 2008, and 2013**

	Students who took an AP exam (number)			Students who passed an AP exam (number)[a]			Students who passed an AP exam (%)[a]		
Subject	2003	2008	2013	2003	2008	2013	2003	2008	2013
Any AP exam	514,163	756,708	1,003,430	331,734	460,785	607,505	64.5	60.9	60.5
Any AP mathematics or science exam	272,580	396,232	527,001	166,582	222,931	291,946	61.1	56.3	55.4
AP mathematics exam									
Calculus AB	131,951	176,864	223,444	86,048	104,722	128,940	65.2	59.2	57.7
Calculus BC	36,619	55,323	78,291	29,252	43,769	62,965	79.9	79.1	80.4
Statistics	48,345	92,692	141,335	28,967	53,581	80,529	59.9	57.8	57.0
AP science exam									
Biology	80,000	121,554	162,381	47,544	64,718	90,198	59.4	53.2	55.5
Chemistry	51,105	79,242	107,431	29,469	42,685	58,536	57.7	53.9	54.5
Environmental science	22,039	50,118	97,918	10,896	25,860	46,733	49.4	51.6	47.7
Computer science A	12,090	12,258	22,273	7,551	7,003	14,293	62.5	57.1	64.2
Physics B	31,650	46,009	68,802	18,412	26,555	41,278	58.2	57.7	60.0
Physics C: electricity /magnetism	7,581	9,349	14,045	4,941	6,387	9,458	65.2	68.3	67.3
Physics C: mechanics	16,042	21,994	31,959	11,322	15,789	23,472	70.6	71.8	73.4

AP = Advanced Placement.

[a] Students scoring 3, 4, or 5 on a scale of 1–5 for an AP exam.

NOTES: The College Board reports AP results by graduating class rather than by calendar year. Results include exams taken by graduates throughout their high school career.

SOURCE: The College Board, *The 10th Annual AP® Report to the Nation—Subject Supplement*. Copyright © 2014, www.collegeboard.org. Reproduced with permission.

Science and Engineering Indicators 2016

The number of high school graduates who take at least one AP exam doubled in the 10 years from 2003 to 2013. In contrast, the overall high school population increased by just 9% between 2001 and 2013 (U.S. DOE 2015). In 2013, just over 1 million students took one or more AP exams in any subject, almost twice the 514,000 students who took an AP exam in 2003. Similarly, the number of students who took an AP exam in mathematics or science rose from 273,000 in 2003 to 527,000 in 2013. The AP statistics exam continued to grow in popularity, with 141,000 students taking the exam in 2013, compared with 48,000 in 2003. Though still representing a small proportion of overall AP exams, the computer science A exam has also grown over the past 10 years, with 22,000 students taking the exam in 2013, compared with 12,000 in 2003 and 2008.

The growing number of students taking AP exams over the past decade was accompanied by a decline in the overall passing rate, even as rates for some individual exams have risen or remained steady. In 2013, 61% of students who took one or more AP exams had passed at least one exam, compared with 65% in 2003. For mathematics and science exams, the passing rate was 55%; the corresponding 2003 passing rate was 61%.

Passing rates were highest for the more advanced exams. In 2013, the passing rate for calculus BC was 80% (the highest of any exam), compared with 58% for calculus AB. The passing rate was 73% for physics C: mechanics, 67% for physics C: electricity and magnetism, but 60% for physics B. The lowest passing rate for any AP mathematics or science exam was 48% for the environmental science exam. Despite the growth in the number of AP test takers, the College Board estimates that 60% of students who have the potential to succeed in AP coursework (based on performance on sections of the Preliminary SAT/National Merit Scholarship Qualifying Test) do not participate in AP courses (College Board 2014).

AP Exam Taking and Performance by Sex and Race or Ethnicity

Mathematics and science AP exam taking at the most advanced levels varies with students' sex and race or ethnicity. Although the students who took calculus AB, statistics, and chemistry exams were roughly evenly split by sex, at advanced levels male students predominated, representing 59% of all calculus BC takers, 65% of physics B, 77% of physics C: electricity and magnetism, and 74% of physics C: mechanics (Figure 1-10).

In addition, black and Hispanic students are underrepresented among AP exam takers, particularly among more advanced mathematics and science courses (College Board 2014). Black students made up 15% of 2013 high school graduates but only 3% of students who took the calculus BC or either physics C exam (Appendix Table 1-12). Hispanic students made up 19% of graduates but less than 10% of exam takers in calculus BC (8%), physics C: electricity and magnetism (7%), and physics C: mechanics (9%). On the other hand, Asians or Pacific Islanders were overrepresented among AP exam takers, accounting for 6% of graduates but about 30% of exam takers in physics C: electricity and magnetism and in calculus BC.

Racial and Ethnic Differences in Advanced Mathematics and Science Coursetaking: Civil Rights Data

OCR collects data from U.S. primary and secondary schools about students' demographics and access to high school–level mathematics and science courses. These data provide an additional look at racial and ethnic differences in high school mathematics and science coursetaking. In the most recent academic year with data available, 2009–10, enrollments in lower-level courses such as geometry and biology show little differentiation across racial and ethnic and groups (Appendix Table 1-13). For example, 22% of all students were enrolled in geometry, including 22% of white students, 22% of Hispanic students, 23% of Asian or Pacific Islander students, and 20% of American Indian or Alaska Native students.[i] However, in high-level courses such as calculus, fewer black and Hispanic students were enrolled relative to Asian or Pacific Islander and white students: 3% of all students were enrolled in calculus, including 4% of white students, 9% of Asian or Pacific Islander students, 2% of black students, and 1% each among Hispanic and American Indian or Alaska Native students.

---

[i] No estimate was available for black students.

Teachers of Mathematics and Science

Students' achievement in mathematics and science depends not only on the courses they take but also, in large part, on their access to high-quality instruction. Many factors affect teacher quality, including qualifications, subject-matter knowledge, ongoing professional development, access to instructional coaches, and working conditions (Campbell and Malkus 2011; Creemers, Kryiakides, and Antoniou 2013; DeMonte 2013; Eckert 2013; Johnson, Kraft, and Papay 2012; Schmidt et al. 2008; Shober 2012; Wilson 2011). This section presents various indicators of public school mathematics and science teachers' quality, including educational attainment, professional certification, participation in student teaching, self-assessment of preparation, and years of experience. The section also examines school factors, such as salary and working conditions, that contribute to teacher effectiveness. It focuses on middle and high school teachers because mathematics and science teachers are more common and more easily identified at these levels than at the elementary level.[i] The main finding in this section is that highly qualified teachers, as measured by any of the indicators presented here, are less prevalent at high-poverty and high-minority schools.

The primary data source is the 2011−12 SASS, a national survey designed to provide descriptive data on elementary and secondary education across a wide range of topics, including teacher demand, teacher and principal characteristics, general conditions in schools, principals' and teachers' perceptions of their school climate and problems in their schools, teacher compensation, and district hiring and retention practices. Comparable data from earlier SASS collections in 2003−04 and 2007−08 are also used to examine changes over time. In this section, 2003, 2007, and 2011 refer to the academic years 2003−04, 2007−08, and 2011−12. When possible, measures are analyzed separately for schools with differing concentrations of minority and low-income students.[ii]

To provide context, the total number of U.S. public school teachers was about 3.4 million in 2011 (Appendix Table 1-14), a 13% increase over the approximately 3.0 million teachers employed in 1999 (Gruber, Wiley, and Broughman 2002). In 2011, approximately 509,000 taught mathematics or science in public schools, accounting for 15% of the public school teaching force nationwide. Most subject-specific mathematics and science teachers (approximately 415,000, or 82%) taught at the middle and high school levels. The number of elementary teachers at public schools in 2011 was approximately 1.8 million, and the majority of those teachers taught mathematics and science in addition to other subjects.

---

[i] Middle and high school teachers included in this section are identified using an NCES Schools and Staffing Survey (SASS) variable that indicates the level of the school at which teachers are employed. Middle schools are defined as those with no grade lower than 5 and no grade higher than 8; high schools are defined as those with no grade lower than 7 and at least one grade higher than 8. Elementary school teachers, not included in these indicators, typically teach multiple subjects, and most of them hold a certification in general education.

[ii] Based on the percentage of students in school qualifying for free/reduced-price lunch.

Characteristics of High-Quality Teachers

The effects of good teachers on student achievement have been well documented (Boonen, Van Damme, and Onghena 2014; Hanushek 2011; Harris and Sass 2011; Jackson, Rockoff, and Staiger 2014; Stronge, Ward, and Grant 2011), but the specific teacher characteristics that contribute to student success remain less clear. Some studies have cast doubt on whether commonly measured indicators, such as teachers' licensure scores or the selectivity of their undergraduate institutions, are related to teaching effectiveness (Boyd et al. 2006; Buddin and Zamarro 2009a, 2009b; Hanushek and Rivkin 2006). This section reports on indicators such as public school mathematics and science teachers' educational attainment, professional certification, participation in student teaching, self-assessment of preparation, and years of experience. Other less easily observed characteristics may also contribute to teacher effectiveness, including teachers' abilities to motivate students, engage students in learning, maximize instruction time, and diagnose and overcome students' learning difficulties. However, these characteristics are often difficult and costly to measure and therefore are rarely included in nationally representative surveys.

Highest Degree Attained

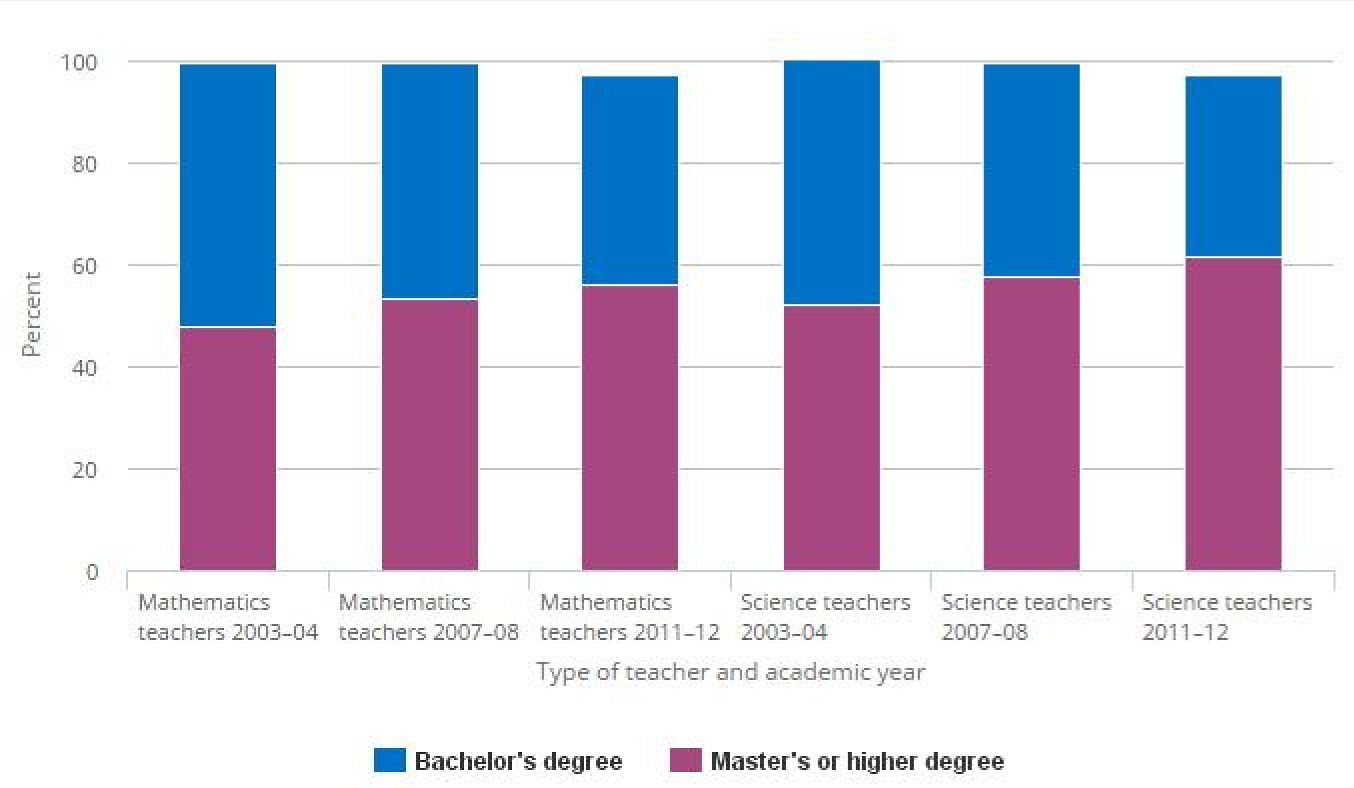
Although teachers with master's degrees typically earn additional salary or stipends, research suggests that these degrees are not associated with improved student achievement (Harris and Sass 2007; Leak and Farkas 2011). There are studies, however, that suggest that master's degrees in math and science are associated with a positive effect on student achievement in those subjects (Miller and Roza 2012). The data available from SASS do not break advanced degrees down by subject area, but available data are reported here because of general interest in teacher qualifications. Virtually all mathematics and science teachers at public middle and high schools in 2011 held at least a bachelor's degree, and more than half had earned an additional degree (e.g., master's degree, education specialist, certificate of advanced graduate studies, doctorate, professional degree) (Figure 1-11). The proportion of middle and high school mathematics and science teachers with a master's degree or higher has increased since 2003, from 48% to 56% in 2011 for mathematics teachers and from 52% to 61% for science teachers (Appendix Table 1-15). But teachers with master's degrees were not evenly distributed across schools. For example, in 2011, 71% of science teachers in low-poverty schools had earned a master's or higher degree, compared with 52% of those in high-poverty schools (Table 1-13).[i]

---

[i] To simplify the discussion, schools in which 10% or fewer of the students are eligible for the federal free /reduced-price lunch program are called *low-poverty schools,* and schools in which more than 50% of the students are eligible are called *high-poverty schools.* Similarly, *low-minority schools* are those in which 5% or fewer of the students are members of a minority, and *high-minority schools* are those in which more than 45% of the students are members of a minority.

Figure 1-11

Public middle and high school mathematics and science teachers who had a bachelor's or higher degree: Academic years 2003–04, 2007–08, and 2011–12



SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2014) of 2003–04, 2007–08, and 2011–12 Schools and Staffing Survey, National Center for Education Statistics. See appendix table 1-15.

Science and Engineering Indicators 2016

Table 1-13 Public middle and high school mathematics and science teachers with a master's or higher degree, by minority enrollment and school poverty level: Academic year 2011–12

(Percent)

School characteristic	Mathematics teachers	Science teachers
Minority enrollment (%)		
0–5	58.2	63.7
> 5–45	57.6	67.1
> 45	54.0	54.6
School poverty level (%)[a]		
0–10	62.3	71.1
> 10–50	54.9	65.9
> 50	55.0	52.1

	[a] School poverty level is percentage of students in school qualifying for free/reduced-price lunch.
SOURCE:	National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2014) of 2011–12 Schools and Staffing Survey, National Center for Education Statistics. See appendix table 1-15.
	Science and Engineering Indicators 2016

Certification and Entry into the Profession

All public school teachers must have some type of state certification to teach. The traditional path to becoming a teacher begins in an undergraduate education program, where future teachers earn a bachelor's or master's degree and full teaching certification prior to beginning to teach. In recent years, a growing proportion of new teachers have entered the profession through an alternative pathway that typically involves a program that recruits college graduates from other fields or midcareer professionals in nonteaching positions. These teachers often begin to teach with probationary or temporary certification while they work toward regular certification during the first few years of their teaching careers.[ii]

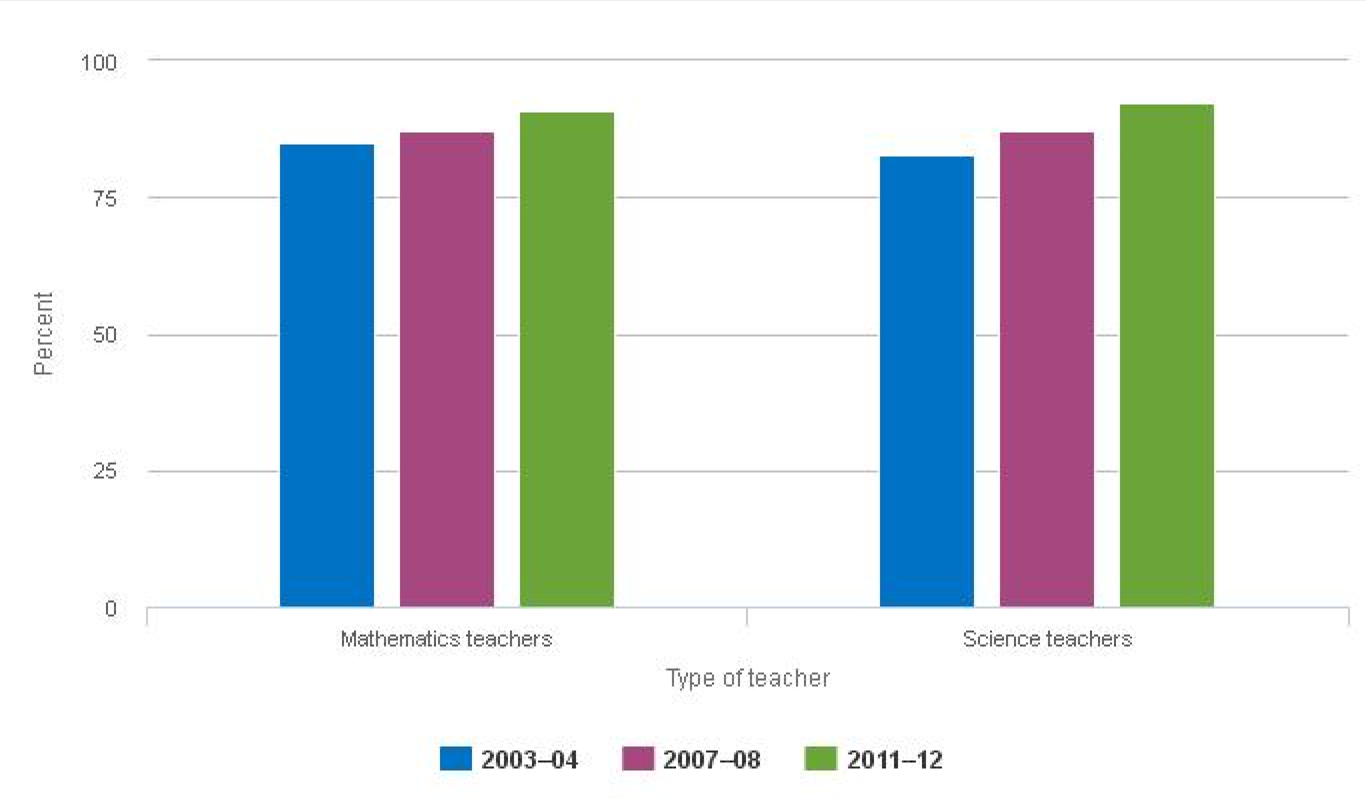
State certification. Each state requires public school teachers to earn a certificate that licenses them to teach. States set criteria for various types of certification; usually, a full certification entails a combination of passing scores on tests, a bachelor's degree with a specified number of credits in education and in the discipline taught, and supervised student teaching experience (NCTQ 2013). In 2011, 25 states required prospective teachers to have a major in a content-specific subject area for at least one initial credential at the secondary level, whereas 20 states had the same requirement at the middle school level and 13 at the elementary level (U.S. Department of Education 2013b). Differences in state standards and requirements for certification complicate measurement of the effect of teachers' credentials on student outcomes; this may have contributed to the research finding that teacher certification has mixed effects on student achievement (Guarino et al. 2013; Jacob 2012; Leak and Farkas 2011; Mo, Singh, and Chang 2013).

In 2011, the vast majority of public middle and high school mathematics and science teachers (91% and 92%, respectively) were fully certified (i.e., held regular or advanced state certification) (Figure 1-12). The percentage of mathematics and science teachers with full state certification has increased by 6 percentage points and 9 percentage points, respectively, from 2003 to 2011. The increase was seen in many types of schools but was more apparent among science teachers in high-minority schools (from 79% in 2003 to 90% in 2011) and high-poverty schools (from 80% to 91%) (Appendix Table 1-16).

[ii]Probationary certification generally is awarded to those who have completed all requirements except for a probationary teaching period. Provisional or temporary certification is awarded to those who still have requirements to meet. States also issue emergency certification to those with insufficient teacher preparation who must complete a regular certification program to continue teaching. Teachers' type of certification differs from their pathway into the profession: teachers from both traditional and alternative programs may have any type of state certification enabling them to teach. Alternative-pathway teachers, however, are more likely to begin teaching with a provisional or temporary certification.

Figure 1-12

Public middle and high school mathematics and science teachers who held a regular or advanced certification: Academic years 2003–04, 2007–08, and 2011–12



SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2014) of 2003–04, 2007–08, and 2011–12 Schools and Staffing Survey, National Center for Education Statistics. See appendix table 1-16.

Science and Engineering Indicators 2016

Despite these increases, fully certified mathematics and science teachers were still less prevalent in high-minority and high-poverty schools when compared with schools with more advantaged students. For example, 88% of mathematics teachers in high-poverty schools were fully certified, compared with 95% of those in low-poverty schools (Table 1-14). The share of fully certified science teachers was 91% in high-minority schools, slightly lower than the 95% in low-minority schools.

Table 1-14

Public middle and high school mathematics and science teachers with a regular or advanced certification, by minority enrollment and school poverty level: Academic year 2011–12

(Percent)

School characteristic	Mathematics teachers	Science teachers
Minority enrollment (%)		
0–5	94.4	94.8
> 5–45	92.5	94.5

School characteristic	Mathematics teachers	Science teachers
> 45	88.6	89.5
School poverty level (%)[a]		
0–10	95.2	95.0
> 10–50	91.9	92.8
> 50	88.2	90.6

[a] School poverty level is percentage of students in school qualifying for free/reduced-price lunch.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2014) of 2011–12 Schools and Staffing Survey, National Center for Education Statistics. See appendix table 1-16.

Science and Engineering Indicators 2016

Alternative entry into the teaching profession. Rather than completing traditional undergraduate programs in education, some teachers enter teaching through alternative programs such as Teach for America, The New Teacher Project (TNTP), and other programs administered by states, districts, universities, and other organizations to expedite the transition of nonteachers into teaching. Some alternative entry programs place recruits in *high-need schools*—generally, those with high levels of student poverty and low levels of student achievement. According to its website, TNTP has recruited or trained nearly 50,000 teachers for high-need locations since 1997; Teach for America's annual placement of teachers in high-need schools has grown from about 900 to more than 10,000 between 1995 and 2013 (Teach for America 2013). Although data are not available on the number of mathematics and science teachers placed by these programs, the goals of both TNTP and Teach for America include increasing the supply of teachers in those subject areas.[iii]

Researchers have observed few systematic differences in the training received by aspiring teachers in traditional versus alternative pathways (Henry et al. 2014; Linek et al. 2012; Sass 2011).[iv] Much of the formal training for teachers in both traditional and alternative programs takes place in schools of education at universities (Walsh and Jacobs 2007). Although SASS data show that a smaller proportion of alternative-pathway teachers participated in student teaching before beginning teaching (see the "Student Teaching" section), research has generally found few clear effects of teachers' pathways into the profession on students' achievement (Gansle, Noell, and Burns 2012; Goldhaber, Liddle, and Theobald 2013; Harris and Sass 2011). Some studies have found that teachers from particular programs, such as Teach for America, may be more effective in teaching STEM subjects than teachers with other types of preparation (Henry et al. 2014).

SASS asked teachers whether they entered the teaching profession through an alternative certification program designed to expedite the transition of nonteachers to a teaching career (e.g., a state, district, or university alternative certification program). In 2011, 18% of public middle and high school mathematics teachers and 26% of science teachers had entered the profession through an alternative certification program, compared with 17% of teachers in other fields (Table 1-15). The number of science teachers who had entered the profession through this pathway has risen somewhat in recent years, from 22% in 2007 to 26% in 2011 (Appendix Table 1-17).

[iii] In 2011, states reported 439 alternative-route teacher programs offered at postsecondary institutions (U.S. Department of Education 2013b). Some programs, such as Teach for America, receive direct federal support, and others are themselves federal programs, such as the U.S. Department of Defense's Troops to Teachers program, which facilitates the entry of military personnel into teaching careers. Race to the Top, a federal competitive grant

program encouraging certain education reforms, awarded points to applicant states for providing high-quality alternative pathways for aspiring teachers. More information about these programs is available at https://www.teachforamerica.org/about-us/our-initiatives/stem-initiative and http://blowmindsteachstem.com/. Information about the Troops to Teachers program is available at http://www2.ed.gov/programs/troops/index.html.

[iv] Large variation has been observed between programs within each pathway (Boyd et al. 2008).

Table 1-15 **Public middle and high school mathematics, science, and other teachers who entered teaching through an alternative certification program, by minority enrollment and school poverty level: Academic year 2011–12**

(Percent)

School characteristic	Mathematics teachers	Science teachers	Other teachers
All schools	17.8	25.6	16.9
Minority enrollment (%)			
0–5	8.9	14.8	10.6
> 5–45	12.3	21.4	13.4
> 45	24.3	32.0	21.8
School poverty level (%)[a]			
0–10	11.6	19.0	11.5
> 10–50	14.6	22.9	13.7
> 50	23.2	31.2	22.2

[a] School poverty level is percentage of students in school qualifying for free/reduced-price lunch.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2014) of 2011–12 Schools and Staffing Survey, National Center for Education Statistics. See appendix table 1-17.

Science and Engineering Indicators 2016

Teachers who had entered through alternative programs were more concentrated in schools with high rates of minority enrollment and school poverty, reflecting the recruiting priority that these programs place on high-need schools. For example, 23% of mathematics teachers in high-poverty schools had entered teaching through an alternative program, compared with 12% of those in low-poverty schools (Table 1-15). The percentage of science teachers in high-poverty schools who had entered teaching through an alternative program was 31%, compared with 19% of science teachers in low-poverty schools. Although the supply of mathematics and science teachers generally has been adequate to fill vacancies due to retirement of mathematics teachers, many schools find it difficult to fill their mathematics and science teaching positions due to preretirement teacher turnover (Goldhaber et al. 2014; Ingersoll 2011; Ingersoll and May 2012). Teacher shortages in these subjects are not distributed evenly across schools. High-poverty and high-minority schools in urban areas tend to have the highest rates of teacher turnover. The resulting shortages may contribute to schools' decisions to hire teachers from alternative entry programs.

Student Teaching

Student teaching offers prospective teachers hands-on classroom experience to help them transfer what they learn from coursework into classroom teaching. Practical experience in the classroom may also affect student achievement once teachers enter the classroom (Ronfeldt 2012; Ronfeldt and Reininger 2012).[v] According to

SASS data, teachers who had participated in student teaching were generally more likely than those who had not to report feeling well, or very well, prepared for various aspects of their first year of teaching (Appendix Table 1-18).

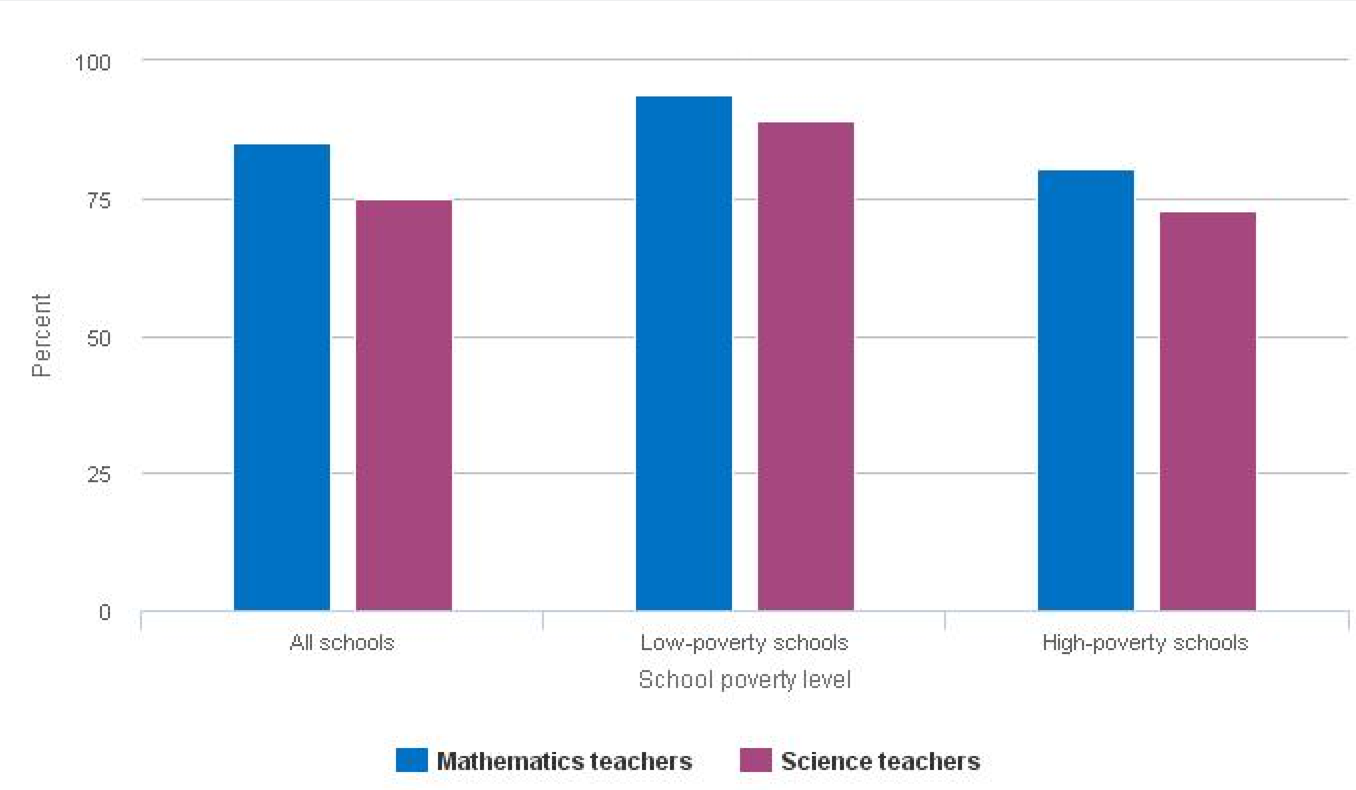
Among public middle and high school mathematics and science teachers with fewer than 5 years of experience in 2011, 85% of mathematics teachers and 75% of science teachers had participated in student teaching (Figure 1-13). The proportion differed by school composition; for example, 94% of new mathematics and 89% of new science teachers in low-poverty schools participated in student teaching, compared with 80% and 73%, respectively, in high-poverty schools (Appendix Table 1-19).

---

[v] Research suggests that characteristics of the student teaching placement program affect subsequent teacher effectiveness. In New York City, teachers who were placed in easy-to-staff schools during their student teaching were more likely to remain teaching in the district and see gains in student achievement, regardless of the characteristics of the school at which they were ultimately employed (Ronfeldt 2012). Teachers whose preparation programs provided oversight of their student teaching and required a capstone project saw larger student achievement gains during their first year (Boyd et al. 2008).

Figure 1-13

Participation of new public middle and high school mathematics and science teachers in practice teaching, by school poverty level: Academic year 2011–12



NOTES: New teachers refer to teachers with fewer than 5 years of teaching experience. School poverty level is percentage of students in school qualifying for free/reduced-price lunch. Schools with 0%–10% of such students are low-poverty schools, and schools with more than 50% of such students are high-poverty schools.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2014) of 2011–12 Schools and Staffing Survey, National Center for Education Statistics. See appendix table 1-19.

Science and Engineering Indicators 2016

Although student teaching is prevalent, many teachers who entered the profession through alternative programs report not participating in student teaching. In 2011, 48% of mathematics teachers and 52% of science teachers who entered the profession through an alternative program had not participated in student teaching, lower than the 94% of mathematics and science teachers who entered teaching the traditional way (Appendix Table 1-20). Thirty-nine states require prospective teachers in traditional preparation programs to participate in student teaching, whereas 16 states require that all alternative-route teachers have an opportunity to student teach (NCTQ 2011, 2013).

Self-Assessment of Preparedness

New middle and high school teachers generally reported that they felt well prepared to perform various tasks during their first year of teaching (Appendix Table 1-21). In 2011, 87% of new mathematics teachers and 90% of new science teachers felt prepared to teach their subject matter. Among new science teachers, this represents an increase since 2003, when 79% felt prepared to teach the subject matter. A larger proportion of new science teachers also reported feeling prepared to assess students (70% in 2011 versus 59% in 2003). New teachers' assessments of their preparation were lower in high-minority and high-poverty schools. For example, in 2011, 95% of new mathematics teachers in low-poverty schools felt prepared to teach their subject matter, compared with 83% of their peers in high-poverty schools (Appendix Table 1-21).

Experience

Teachers generally are more effective in helping students learn as they gain years of experience, particularly during their first few years (Harris and Sass 2011; Kraft and Papay 2014; Ladd and Sorensen 2014; Rice 2013; Wiswall 2013). Some studies have shown a positive relationship between student achievement and the number of years of teacher experience (Chingos and Peterson 2011; Ng, Nicholas, and Williams 2010), suggesting that experience may be an important characteristic of effective teachers. Although the percentage of teachers of mathematics with more than 20 years of experience decreased from 29% in 2003 to 23% in 2011, the percentage of teachers with 10–19 years of experience increased from 27% to 33%, and the percentage of teachers with less than 3 years of experience decreased from 19% to 15% (Appendix Table 1-22). The pattern among science teachers was similar. Overall, in 2011, 85% of public middle and high school mathematics teachers and 90% of science teachers had more than 3 years of experience.

Recent studies have found, however, that novice teachers (i.e., teachers with 3 years or fewer of experience) are more likely than experienced teachers to work in high-poverty and high-minority schools, suggesting that students in these schools may have fewer effective teachers (Loeb, Kalogrides, and Béteille 2012; LoGerfo, Christopher, and Flanagan 2012; Sass et al. 2012). In 2011, some 15% of public middle and high school mathematics teachers and 10% of science teachers were novices with 3 years or less of experience (Table 1-16). Proportionally more mathematics teachers in high-minority schools and high-poverty schools were novice teachers than in low-minority schools (19% versus 10%) and low-poverty schools (18% versus 10%). The pattern was similar for science.

Table 1-16 **Public middle and high school mathematics and science teachers with less than 3 years of teaching experience, by minority enrollment and school poverty level: Academic year 2011–12**

(Percent)

School characteristic	Mathematics teachers	Science teachers
All schools	14.9	10.4
Minority enrollment (%)		
0–5	10.2	11.6
> 5–45	11.8	8.2
> 45	18.6	12.7
School poverty level (%)[a]		
0–10	10.3	8.7
> 10–50	13.3	9.0
> 50	18.1	12.9

[a] School poverty level is percentage of students in school qualifying for free/reduced-price lunch.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2014) of 2003–04, 2007–08, and 2011–12 Schools and Staffing Survey, National Center for Education Statistics. See appendix table 1-22.

Science and Engineering Indicators 2016

School Factors Contributing to Teachers' Effectiveness

Teachers bring a variety of knowledge, skills, and experience into their classrooms, but conditions in their schools and districts also influence their effectiveness in promoting student outcomes and their decisions about remaining in the profession. This section presents indicators of district and school attributes that affect teachers' success, including the assignment of teachers to subjects, initial and ongoing professional development, salaries, and working conditions.

In-Field Teaching

In-field teaching assignment in middle and high schools has been found in some studies to have a positive correlation with teacher knowledge and student mathematics achievement (Lee 2012; Sung and Yang 2013). Its inverse, *out-of-field teaching,* is associated with teacher attrition and lack of content knowledge and may be more prevalent than previously recognized (Hill and Dalton 2013; Hobbs 2015). In recognition of the potential benefits associated with in-field teaching, the No Child Left Behind Act of 2001 (NCLB) mandated that all students have teachers who demonstrate competence in subject knowledge and teaching. NCLB provided specific guidance and criteria for adequate preparation to teach mathematics and science to the states.

To determine whether teachers have subject-specific preparation for the fields they teach, research has focused on matching teachers' formal preparation (as indicated by degree major and certification field) with their teaching field (Hill and Gruber 2011; Morton et al. 2008). Following this line of research, the National Science Board distinguished four levels of formal preparation for teaching mathematics and science at the middle and high school levels (NSB 2010). Mathematics teachers with the most rigorous preparation—that is, those teaching *in field*—had a degree, full certification, or both in mathematics or mathematics education. Similarly, in-field science teachers had a degree, full certification, or both in science or science education.

The push for the highly qualified teachers mandated by NCLB appears to have had a significant effect on the percentage of middle school mathematics and science teachers who meet this rigorous definition of preparation. The percentage of middle school mathematics and science teachers with in-field degrees has increased steadily since 2003 (Table 1-17). In 2011, two-thirds of middle school mathematics teachers and three-quarters of middle school science teachers had in-field degrees. The level of in-field mathematics and science teachers in high schools has not changed significantly since 2003, remaining steady at about 90% for mathematics and biology/life sciences teachers and 80% for physical sciences teachers.

Table 1-17 **Preparation of public middle and high school mathematics and science teachers for teaching in their field: Academic years 2003–04, 2007–08, and 2011–12**

(Percentage distribution)

	Academic year 2003–04				Academic year 2007–08				Academic year 2011–12			
Teaching level /field	In field [a]	Related field [b]	General education [c]	Other [d]	In field [a]	Related field [b]	General education [c]	Other [d]	In field [a]	Related field [b]	General education [c]	Other [d]
Middle school												
Mathematics	53.5	3.9	37.5	5.1	64.3	1.6	30.6	3.4	66.7	0.7	28.3	4.3
Science	67.0	na	29.2	3.8	69.7	na	27.0	3.3	74.2	na	23.4	2.4
High school												
Mathematics	87.4	2.0	3.1	7.5	88.0	1.2	3.4	7.4	90.1	1.0	4.1	4.8
Biology/life sciences	91.9	3.6	1.3	3.2	93.2	3.9	0.9	2.0	90.0	5.1	2.6	2.3
Physical sciences	78.1	19.6	0.9	1.5	81.6	15.4	1.2	1.8	79.1	16.6	1.0	3.4

na = not applicable.

[a] Mathematics teachers with a degree and/or full certification in mathematics or mathematics education. Science teachers with a degree and/or full certification in science or science education.

[b] Mathematics teachers with a degree and/or full certification in a field related to mathematics (e.g., science, science education, computer sciences, engineering). Science teachers with a degree and/or full certification in a field related to their teaching field (e.g., high school biology teachers with a degree and/or full certification in chemistry). This category is omitted for middle school science teachers because science teachers at this level are usually not distinguished by specific science fields such as physics, chemistry, or biology.

[c] Mathematics and science teachers with a degree and/or full certification in general elementary, middle, or secondary education.

[d] Mathematics and science teachers without a degree or certification in their teaching field, a related field, or general elementary, middle or secondary education.

NOTE: Percentages may not add to total because of rounding.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2014) of 2003–04, 2007–08, and 2011–12 Schools and Staffing Survey, National Center for Education Statistics. See appendix table 1-23.

Science and Engineering Indicators 2016

The percentage of in-field teachers does vary by school poverty level. In 2011, for example, 75% of middle school mathematics teachers in low-poverty schools had in-field degrees, compared with 63% of teachers at high-poverty schools (Appendix Table 1-23). At the high school level, 95% of mathematics teachers at low-poverty schools had in-field degrees, compared with 87% at high-poverty schools. One notable exception was middle school science teachers, 75% of whom had in-field degrees regardless of the school poverty level.

Professional Development for Mathematics and Science Teachers

Professional development enables teachers to update their knowledge, sharpen their skills, and acquire new teaching techniques, all of which may enhance the quality of teaching and learning (Davis, Petish, and Smithey 2006; Richardson and Placier 2001). Although much of the literature on professional development has found little causal evidence of its effectiveness, some research on the effects of individual programs of professional development for elementary and middle school mathematics and science teachers has found positive effects on student achievement (DeMonte 2013; Gersten et al. 2014; Heller et al. 2012). Two types of professional development are discussed here—new teacher professional development through induction and support programs, and ongoing professional development for more experienced teachers.

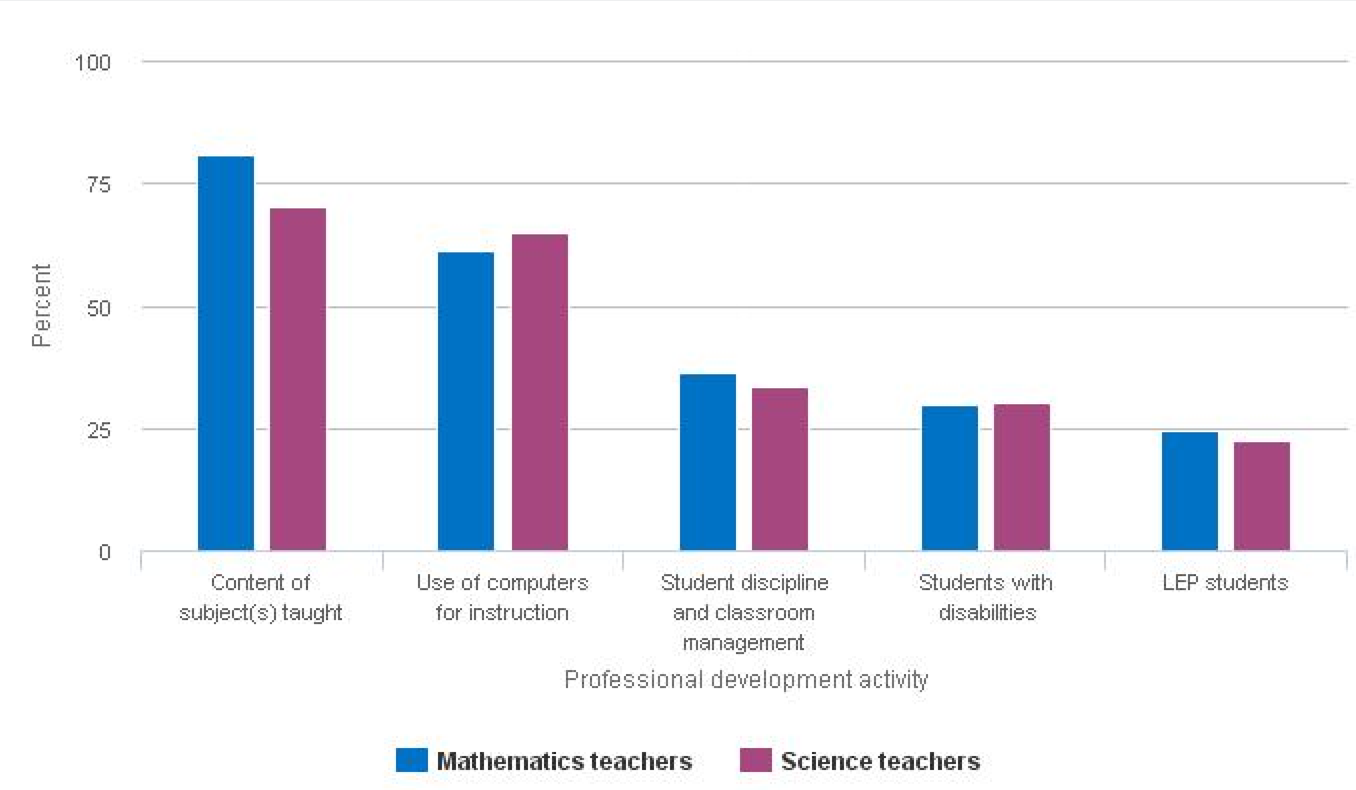
New teacher induction and support. Induction programs for beginning teachers, including support, guidance, and orientation, improve teacher commitment and retention, strengthen teachers' instructional practices, and raise student achievement (Ingersoll and Strong 2011; Wang, Odell, and Clift 2010). Such professional development often begins during a teacher's first year in the classroom, continues in subsequent years, and may prevent early attrition.

Participation in new teacher induction programs has increased markedly since 2003. Among new public middle and high school teachers with fewer than 5 years of experience in 2011, 84% of mathematics and 87% of science teachers had participated in an induction program during their first year, compared with 71% of mathematics teachers and 68% of science teachers in 2003 (Appendix Table 1-24). Teacher participation in induction programs is lower in schools with high concentrations of minority and low-income students, but these gaps have narrowed since 2003. In 2003, 59% of mathematics teachers in high-poverty schools had participated in an induction program, compared with 76% in low-poverty schools, a gap of 17 percentage points. In 2011, that gap was 8 percentage points. The gap narrowed even more in science, with 57% of science teachers in high-poverty schools participating in an induction program in 2003, compared with 77% in low-poverty schools—a gap of 20 percentage points. In 2011, that gap was 8 percentage points. Appendix Table 1-25 shows data on other types of support provided to new teachers when they start their careers.

Ongoing professional development. Ongoing professional development for teachers is often mandated by state regulations and delivered by school districts to teachers throughout their careers. The type of professional development provided for teachers varies substantially, and some types are more effective than others. Simply spending time in professional development activities may not have any effect on student achievement (Garet et al. 2001). The most common types of professional development for mathematics and science teachers in 2011 were subject area instruction and the use of technology in the classroom. In 2011, 81% of mathematics teachers and 70% of science teachers in public middle and high schools received professional development focused on their content area during the preceding 12 months (Figure 1-14). Sixty-one percent of mathematics teachers and 65% of science teachers received professional development in the use of computers for instruction. In comparison, fewer than half received training in classroom discipline or management, teaching students with disabilities, or teaching students with limited English proficiency (Appendix Table 1-26).

Figure 1-14

Participation of public middle and high school teachers in professional development activities during past 12 months, by topic: Academic year 2011–12



LEP = limited English proficiency.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2014) of 2011–12 Schools and Staffing Survey, National Center for Education Statistics. See appendix table 1-26.

Science and Engineering Indicators 2016

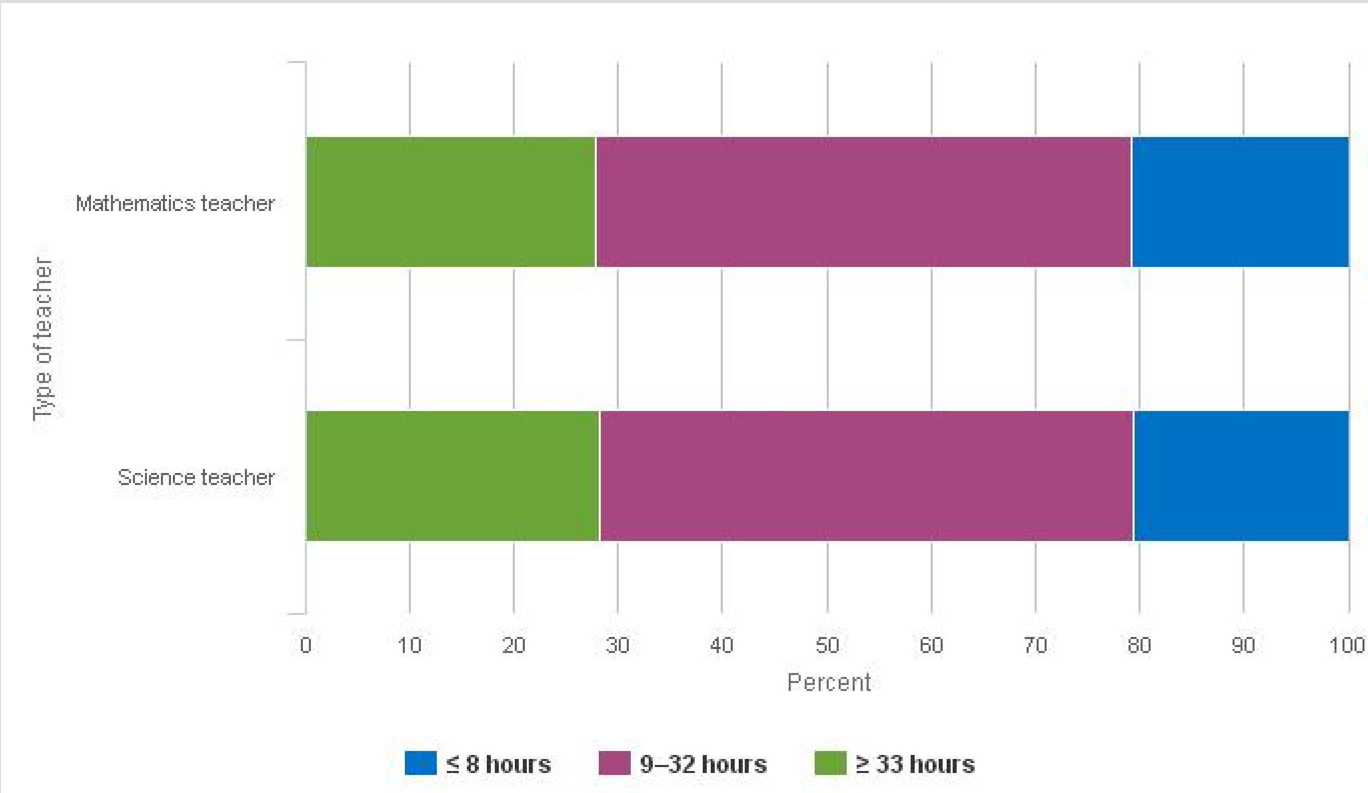
The duration of professional development programs is often shorter than what research suggests may be desirable. More research is needed to establish a threshold; some studies have suggested 80 hours or more of professional development is necessary to affect teacher practice (CCSSO 2009). Among teachers who received professional development in their subject area in 2011, 28% of mathematics and science teachers received 33 hours or more (Figure 1-15).[i]

---

[i] The maximum duration SASS provides as an option in its teacher questionnaire is "33 hours or more," which is reported in this chapter. Research suggests that teachers who receive content-focused professional development already have relatively strong content knowledge (Desimone, Smith, and Ueno 2006).

Figure 1-15

Duration of professional development received by public middle and high school mathematics and science teachers in their subject area during past 12 months: Academic year 2011–12



SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2014) of 2011–12 Schools and Staffing Survey, National Center for Education Statistics. See appendix table 1-26.

Science and Engineering Indicators 2016

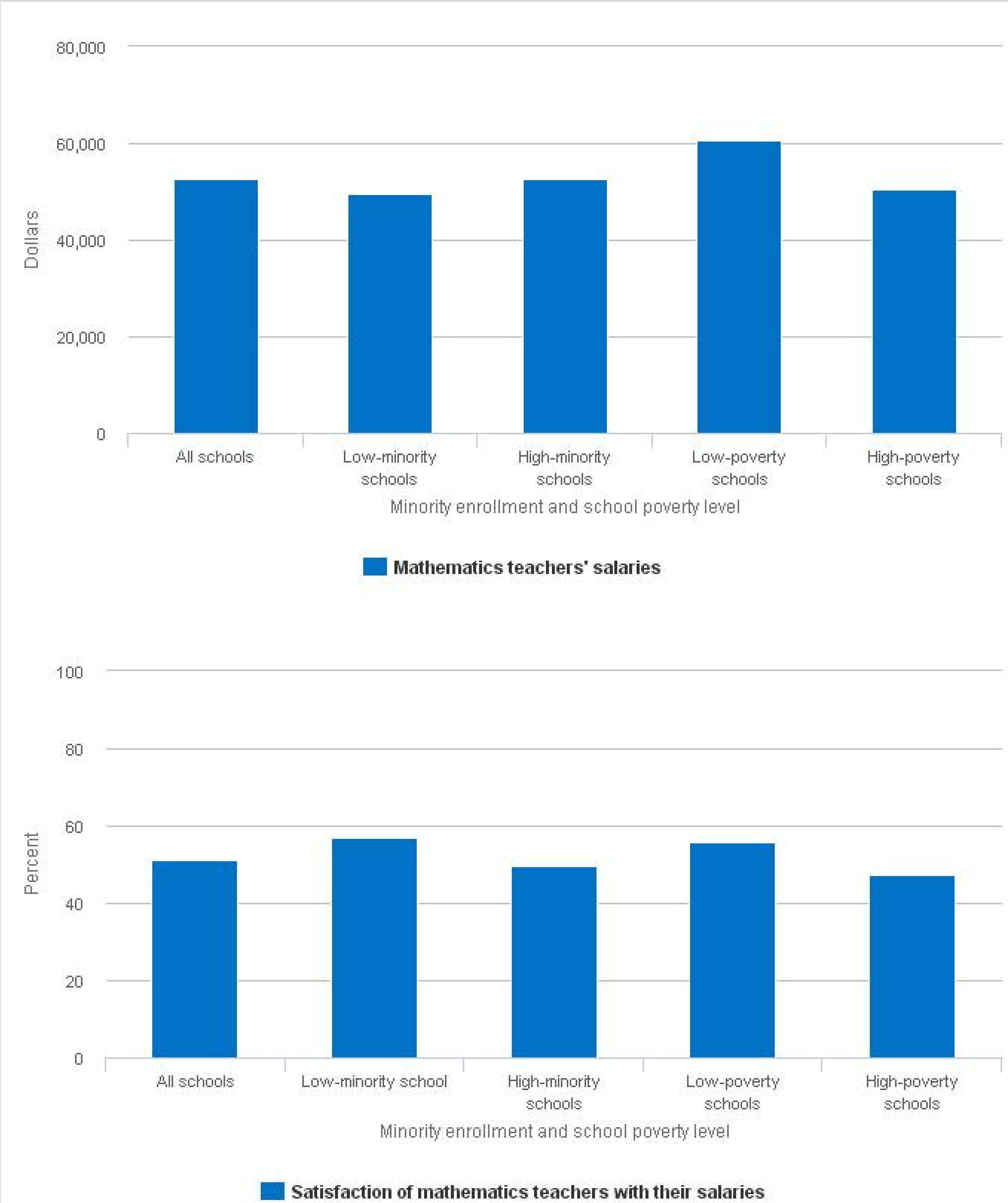
Teacher Salaries

Higher teacher salaries may help keep teachers from leaving the profession (Feng 2014; Gilpin 2012; James et al. 2011; Leigh 2012). In 2007, 15% of school districts offered pay incentives in fields of shortage—usually mathematics, science, and special education—and 10% offered rewards for excellence in teaching (Aritomi and Coopersmith 2009). However, researchers caution that financial incentives may be less effective than factors such as positive working conditions in attracting and retaining high-quality teachers (Berry and Eckert 2012; Rose 2012). Although federal and state strategies have offered financial incentives in an effort to attract quality teachers to hard-to-staff schools, large differences in teacher quality and salary levels persist across and within states (Adamson and Darling-Hammond 2012). Research has indicated that teachers earn less than other professionals with similar levels of education (AFT 2008; Hanushek and Rivkin 2007). The circumstances of employment and the nature of the work differ between teachers and nonteachers, however, and may account for salary differences to some extent. Teachers are more likely than other professionals to work in rural areas, for example, where costs of living and salaries are lower (Taylor 2008). Selecting the appropriate comparison group for teachers also complicates salary comparisons. Some research uses salary data for fields requiring a bachelor's degree (AFT 2008), and at least one study suggests that a smaller set of occupations requiring similar skills may be more appropriate (Milanowski 2008).

In 2011, the average base salary of middle and high school teachers was approximately $53,000 for mathematics teachers and $54,000 for science teachers, based on teachers' reports in SASS (Figure 1-16). Salaries were lowest for mathematics and science teachers at low-minority schools (approximately $50,000 and $49,000 respectively), which may be related to the low number of minority students in rural areas, where teacher pay tends to be lower. Teachers at high-poverty schools earned less than their counterparts at low-poverty schools, with mathematics teachers earning $10,000 less and science teachers earning $13,000 less (Appendix Table 1-27).

Figure 1-16

Average salaries of public middle and high school mathematics teachers and percentage who were satisfied with their salaries, by minority enrollment and school poverty level: Academic year 2011–12



NOTES: Schools with 0%–5% minority enrollment are low-minority schools, and schools with more than 45% minority enrollment are high-minority schools. School poverty level is percentage of students in school qualifying for free/reduced-price lunch. Schools with 0%–10% of such students are low-poverty schools, and schools with more than 50% of such students are high-poverty schools.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2014) of 2011–12 Schools and Staffing Survey, National Center for Education Statistics. See appendix table 1-27.

Science and Engineering Indicators 2016

When asked to rate their satisfaction with their salaries, slightly more than half of mathematics teachers, and just under half of science teachers, reported being satisfied (Figure 1-16; Appendix Table 1-27). Mathematics teachers in low-poverty and low-minority schools were more likely to be satisfied with their salaries than their colleagues in high-poverty and high-minority schools, even though teachers in high-minority schools earned higher base salaries than those in low-minority schools. Patterns were similar among science teachers.

International comparisons of teacher salaries are not available by specific subject, but general comparisons can be made. Organizations such as OECD generally use purchasing power parity to compare salaries across countries. Purchasing power parity reflects the money needed to purchase the same goods and services across countries. By this metric, the United States ranked 6th in teacher pay internationally in 2011 (UNESCO 2014). According to OECD, the United States ranked 11th among OECD countries in 2011 for salaries of teachers with 15 years of experience (OECD 2014).

On average across OECD countries, primary school teachers earn 85% of the salary of college-educated, 25–64-year-old, full-time, full-year workers, whereas lower secondary teachers earn 88% and upper secondary teachers earn 92% of that benchmark salary. The United States ranks 27th among developed countries by this metric, well below the OECD average (OECD 2014).

Teacher Perceptions of Working Conditions

Like salaries, working conditions play a role in determining the supply of qualified teachers and influencing their decisions about remaining in the profession. Safe environments, strong administrative leadership, cooperation among teachers, high levels of parent involvement, and sufficient learning resources can improve teacher effectiveness, enhance teachers' commitment to their schools, and promote job satisfaction, thereby decreasing rates of teacher turnover (Berry and Eckert 2012; Feng 2014; Johnson, Kraft, and Papay 2012; Ladd 2011; Shen et al. 2012). Other studies suggest that schools that have strong leadership opportunities for teachers have greater teacher retention (Harris and Muijs 2004; Schweig 2014).

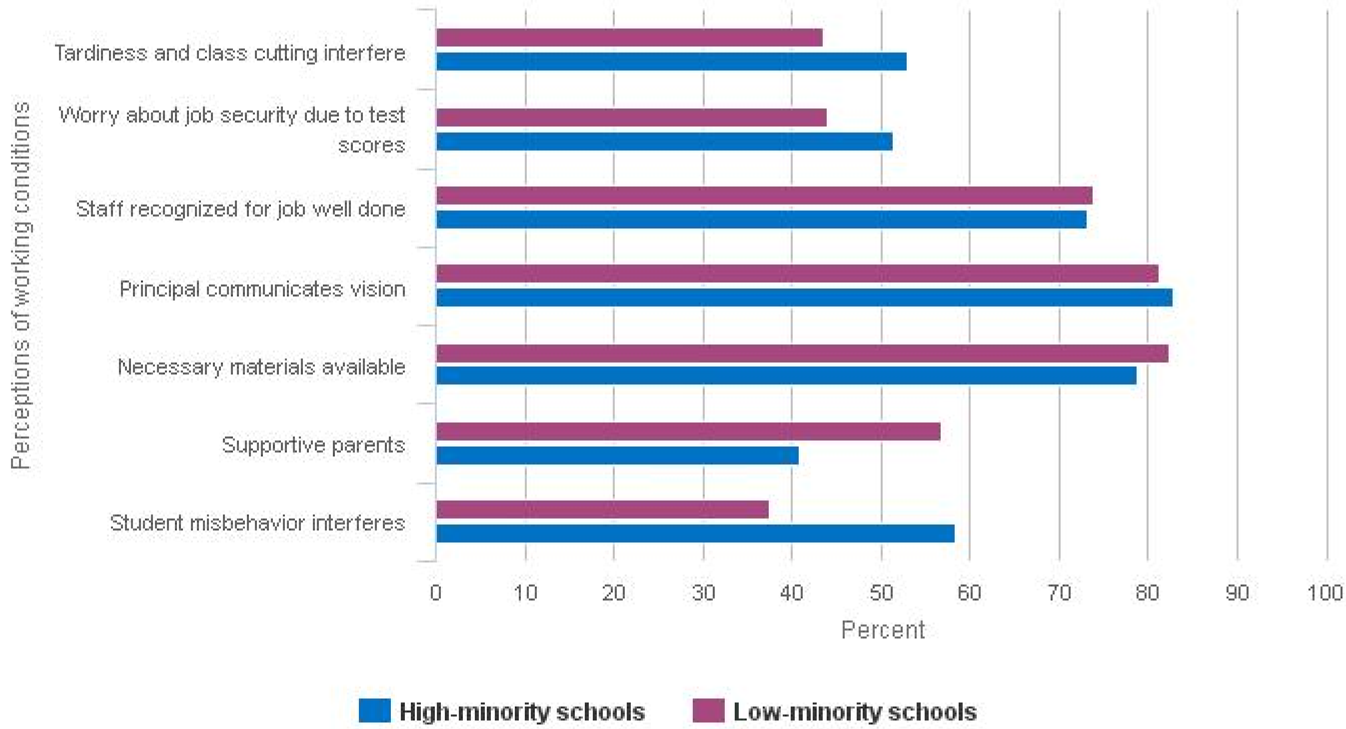
SASS asked teachers at public middle and high schools whether they agreed with several statements about their school environments and working conditions. Majorities of mathematics and science teachers agreed with the following statements in 2011: the school principal knows what kind of school he or she wants and has communicated it to the staff (83% of mathematics and 82% of science teachers); the necessary materials for teaching are available (82% and 77%); and staff are recognized for a job well done (74% and 70%) (Appendix Table 1-28).[ii]

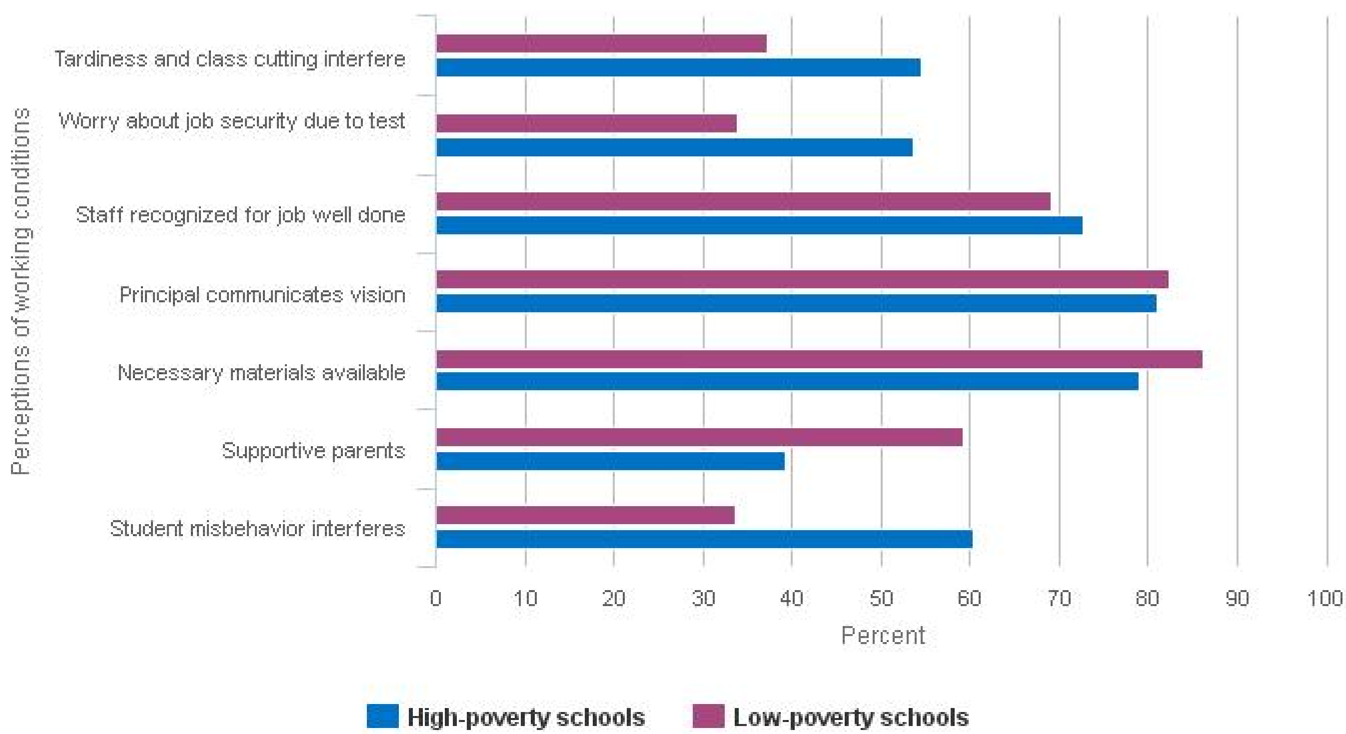
However, responses to some questions—about tardiness, class cutting, misbehavior, and student preparation—revealed differences in school environments between high- and low-poverty schools. For example, about 55% of mathematics and science teachers at high-poverty schools in 2011 reported that students' tardiness and class cutting interfered with teaching, compared with 37% of teachers at low-poverty schools (Figure 1-17; Appendix Table 1-28). Fully 60% of mathematics teachers at high-poverty schools reported student misbehavior interfering with teaching, compared with just over one-third in low-poverty schools.

[ii] The statements about working conditions included in this section represent a selection of those measured in SASS. For a complete list of questions and results for public elementary and secondary teachers, see the *Digest of Education Statistics 2010* (Snyder and Dillow 2011:116, table 76).

Figure 1-17

Perceptions of working conditions of public middle and high school mathematics teachers, by minority enrollment and school poverty level: Academic year 2011–12





NOTES: Teachers were asked to indicate their agreement with various statements about their school conditions. Response categories included Strongly agree, Somewhat agree, Somewhat disagree, and Strongly disagree. Percentages are based on teachers responding Strongly agree or Somewhat agree to various statements. Schools with 0%–5% minority enrollment are low-minority schools, and schools with more than 45% minority enrollment are high-minority schools. School poverty level is percentage of students in school qualifying for free/reduced-price lunch. Schools with 0%–10% of such students are low-poverty schools, and schools with more than 50% of such students are high-poverty schools.

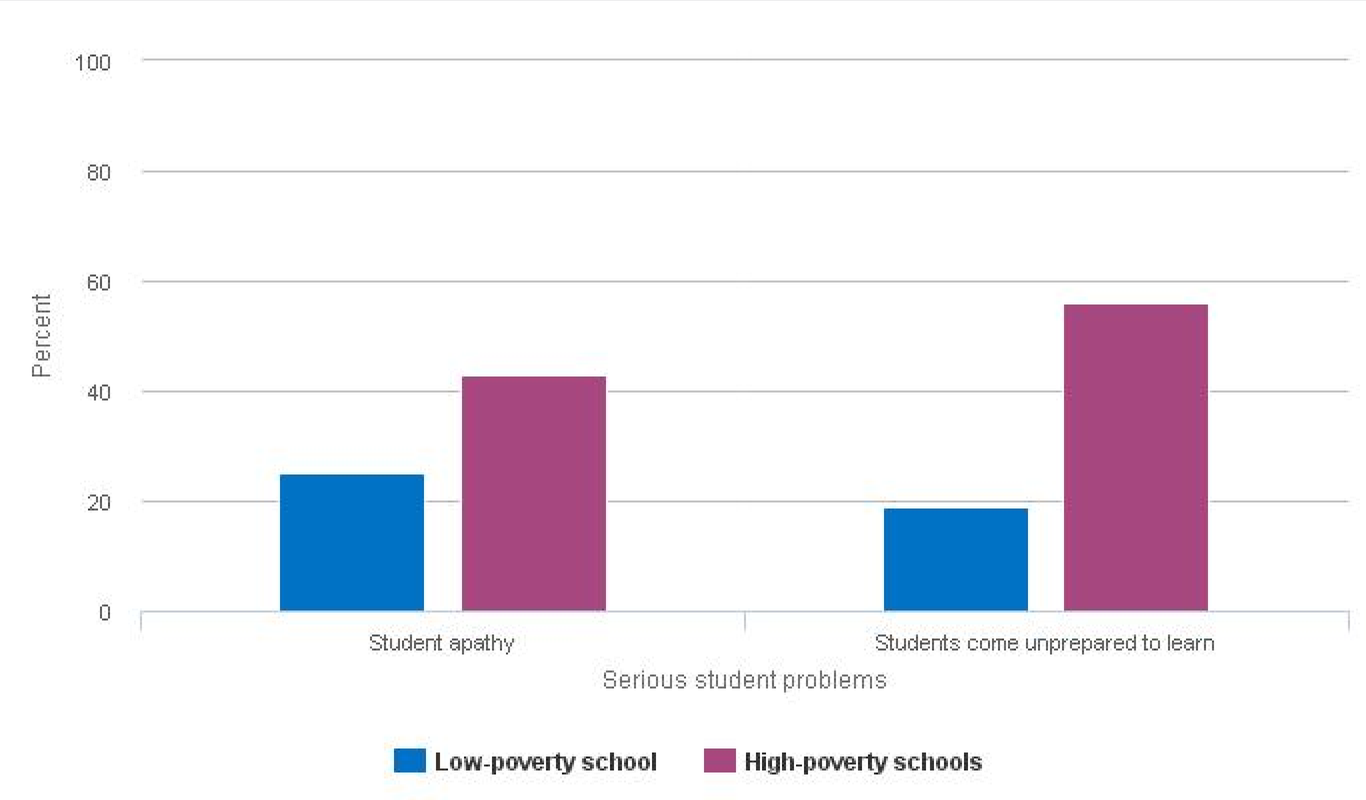
SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2014) of 2011–12 Schools and Staffing Survey, National Center for Education Statistics. See appendix table 1-28.

Science and Engineering Indicators 2016

Lack of student preparation was a serious problem for 56% of mathematics teachers at high-poverty schools in 2011, compared with 19% at low-poverty schools—a gap of 37 percentage points (Figure 1-18). Teacher perceptions of student apathy as a serious problem showed a similar pattern, although the gap was not quite as large: 43% at high-poverty schools, compared with 25% at low-poverty schools. Patterns were similar among science teachers (Appendix Table 1-29).

Figure 1-18

Serious student problems reported by public middle and high school mathematics teachers, by school poverty level: Academic year 2011–12



NOTES: Teachers were asked to indicate the seriousness of various student problems in their schools. Response categories included Serious problem, Moderate problem, Minor problem, and Not a problem. Percentages are based on teachers viewing various student problems as Serious. School poverty level is percentage of students in school qualifying for free/reduced-price lunch. Schools with 0%–10% of such students are low-poverty schools, and schools with more than 50% of such students are high-poverty schools.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2014) of 2011–12 Schools and Staffing Survey, National Center for Education Statistics. See appendix table 1-29.

Science and Engineering Indicators 2016

Some of these problems may be worsening, according to teachers' reports about student apathy and lack of preparation for learning. For example, 34% of all mathematics and 35% of science teachers in 2011 called student apathy a serious problem, compared with 28% and 29%, respectively, in 2007 (Appendix Table 1-29). Again, about 40% of mathematics teachers in 2011, compared with 33% in 2007, identified students' lack of preparation for learning as a serious problem. Similar increases were observed among science teachers.

Instructional Technology and Digital Learning

Over the years, policymakers and researchers have developed a broad consensus that modern technology has great potential to transform education (Duffey and Fox 2012; Johnson et al. 2014; U.S. Department of Education 2010). Support for technology integration in K–12 students' learning has grown and is now widespread. In 2012, 92% of elementary and secondary school principals and 89% of parents of school-aged children reported that technology was so important to student academic success that it should be included in the school's core mission, compared with 77% of school principals and 78% of parents who thought so in 2008 (Project Tomorrow 2013).

Recognizing the potential value of technology, the U.S. federal government has launched a series of initiatives in recent years urging school leaders and educators across the nation to adopt a 21st century model of education that encompasses technology. In 2010, the U.S. Department of Education released a National Education Technology Plan, calling for "revolutionary transformation rather than evolutionary tinkering," leveraging technology to improve teaching, personalize learning, and create engaging learning communities (U.S. Department of Education 2013a:v). In 2013, President Obama announced the ConnectED initiative, pledging to connect 99% of American students to next-generation broadband and high-speed wireless in their schools and libraries within the next 5 years (The White House n.d.). Many states have also joined the federal efforts, taking an active role to build a technology-rich learning environment in their states (Duffey and Fox 2012; NASBE 2012; Watson et al. 2014).

Technology integration in school entails not just providing access to the Internet but also encompasses the strategic use of a broad array of technological tools and practices, including online courses; use of various devices and hardware in classrooms; computer-based assessment; adaptive software for students with special needs; and more. Collectively referred to as *instructional technology,* this wide range of tools and practices involves using and creating appropriate technological processes and resources to facilitate teaching, engage students, and improve learning outcomes (Alliance for Excellent Education 2011; Richey 2008).

This section focuses specifically on the use of technology as an instructional tool in the U.S. K–12 education system. It presents the latest national data on the availability or use of various technological devices in classrooms, Internet access in schools, and the prevalence of online learning among K–12 students. This leads to a review of research on the effectiveness of technology as an instructional tool on student learning outcomes.

Technology as an Instructional Tool

The use of instructional technology—computers, the Internet, mobile devices, interactive whiteboards, and other emerging technologies—in K−12 classrooms has been growing at a rapid pace. Existing national data address the availability or use of technological tools in schools or classrooms, although data and research on the quality and effectiveness of the technologies remain limited (Gray, Thomas, and Lewis 2010a, 2010b; Snyder and Dillow 2013).

Computers and Other Technology Devices

Computers are universally available in U.S. elementary and secondary schools (NSB 2014). As of 2008, all U.S. public K–12 schools had one or more computers for instructional purposes on campus (Gray, Thomas, and Lewis 2010a). Computers are also commonly available in classrooms. In 2009, for example, 97% of K–12 public school teachers reported that they had one or more computers in their classroom, and 69% said that they or their students often or sometimes used computers during class time (Gray, Thomas, and Lewis 2010b). In addition to computers, the majority of teachers reported having the following technology devices either available as needed or in the classroom every day: liquid crystal display (LCD) or digital light processing (DLP) projectors (84%), digital cameras (78%), and interactive whiteboards (51%). Among teachers who reported that these devices were available to them, one-half or more also reported that they used these devices for instruction sometimes or often: 72% of teachers used LCD or DLP projectors, 57% used interactive whiteboards, and 49% used digital cameras.

Despite the widespread access to computers and other devices in classrooms, many teachers still believe they lack technology resources. According to a 2012 national survey conducted by Project Tomorrow, a national education nonprofit organization, 55% of K–12 teachers reported that there were not enough computers for student use in their classes, thus highlighting this deficiency as one of the major obstacles in their use of technology for teaching (Project Tomorrow 2013).

The 2012 National Survey of Science and Mathematics Education sponsored by the National Science Foundation revealed a split between mathematics and science teachers in a nationally representative sample of K–12 teachers about the adequacy of their instructional technology (e.g., computers, calculators, and probes or sensors) (Banilower et al. 2013). Although 69% of high school mathematics teachers indicated that their instructional technology resources were adequate, just 34%–48% of elementary, middle, and high school science teachers indicated the same.

Reported adequacy of technology resources also varied by schools' student achievement levels and composition. Teachers with higher concentrations of low-achieving students, low-income students, and non-Asian minority students had less-positive views on the adequacy of instructional resources. For example, the mean score derived from teachers' responses to the adequacy of instructional resources was 47 for teachers of science classes with mostly low-achieving students, compared with 69 for teachers of science classes with mostly high-achieving students (Table 1-18).

Table 1-18 **Mathematics and science teachers' views of adequacy of instructional resources in class, by class and school characteristics: 2012**

(Mean)

Class and school characteristic	Mathematics teachers	Science teachers
Achievement level of class		
Mostly high achievers	74	69
Average/mixed achievers	70	56
Mostly low achievers	68	47
Percent of non-Asian minority students in class		
Lowest quartile	73	60
Second quartile	71	59
Third quartile	70	58
Highest quartile	69	50
Percent of students eligible for free/reduced-price lunch in school		
Lowest quartile	73	64
Second quartile	71	55
Third quartile	69	54
Highest quartile	68	50

NOTES:	Estimates are class mean scores derived from teachers' evaluation of the adequacy of various instructional resources in class. For mathematics teachers, instructional resources include measurement tools, instructional technology, manipulatives (e.g., pattern blocks), and consumable supplies (e.g., graphing papers). For science teachers, instructional resources include facilities (e.g., lab tables), equipment (e.g., microscopes), consumable supplies (e.g., chemicals), and instructional technology (e.g., computers). Choices of responses range from 1 (not adequate) to 5 (adequate).
SOURCE:	Banilower ER, Smith PS, Weiss IR, Malzahn KA, Campbell KM, Weis AM, *Report of the 2012 National Survey of Science and Mathematics Education*, Horizon Research, Inc. (2013).
	Science and Engineering Indicators 2016

Internet Access and Mobile Devices

Access to the Internet is universal in public K–12 schools in the United States. As of 2008, 100% of public schools had instructional computers with an Internet connection (Gray, Thomas, and Lewis 2010a). In addition, student access to the Internet via instructional computers at school has increased substantially since 2000. In 2008, there were three students per computer with Internet access, compared with seven students per computer with Internet access in 2000 (Gray, Thomas, and Lewis 2010a).

Although Internet access at schools is universal, access with adequate bandwidth and connection speeds remains an area of concern (Fox et al. 2012). In 2010, the Federal Communications Commission (FCC) found that nearly 80% of schools with federal funding for Internet access were not satisfied with their Internet connections (FCC 2010). Slow connection speeds were the primary complaint. In particular, students in high-minority schools were half as likely to have high-speed Internet as students in low-minority schools; low-income students were twice as likely as affluent students to have slow Internet access at their schools; and students in remote rural areas were twice as likely as their urban and suburban peers to have slow Internet access at their schools (Horrigan 2014).

To respond to the federal government's ConnectED initiative for connecting all students to the digital age, in 2014 the FCC dedicated $5 billion in new funds to the existing federal program, the Schools and Libraries program, also known as the E-rate program, to support the construction of high-speed wireless Internet connections on school campuses and library buildings (see sidebar, E-rate Program: Its Purpose and Modernization).

E-rate Program: Its Purpose and Modernization

The Schools and Libraries Program, also known as the E-rate program, is the federal education technology program under the direction of the Federal Communications Commission (FCC). Authorized as part of the Telecommunications Act of 1996, the program was designed to help libraries and K–12 schools in the United States obtain affordable access to the Internet by providing 20%–90% purchase discounts on telecommunications, Internet access, and internal network connections (Jaeger, McClure, and Bertot 2005). For schools, discount rates are based on the percentage of students in the school who are eligible for the National School Lunch Program and by the school's urban-rural classification.

Over the years, the E-rate program has helped U.S. schools and libraries connect to the Internet. When the program was first launched in 1996, only 14% of K–12 classrooms had Internet connections; by 2005, the percentage had risen to 94%. Similarly, just 28% of U.S. public library systems offered Internet access to the public in 1996, but nearly all public libraries around the country (98%) had Internet connections by 2006.*

Despite this growth, the capacity of U.S. K–12 schools and libraries to access Internet content has not kept pace with the latest developments in information and communication technologies. In particular, half of K–12 school buildings have old, slow internal wiring that has difficulty carrying data at today's broadband speeds, and three out of five K–12 schools lack the Wi-Fi needed to access the interactive content of today's Internet (NASBE 2012).

Recognizing these deficiencies, on July 11, 2014, the FCC adopted the E-rate Modernization Order. The order expands funding for Wi-Fi networks and seeks to ensure that the E-rate program meets the broadband needs of schools and libraries in today's world of interactive, individualized digital learning. Through this order, the FCC hopes to accomplish three goals:

- To ensure affordable access to high-speed broadband sufficient to support digital learning in schools and robust connectivity for all libraries
- To maximize the cost-effectiveness of spending for E-rate–supported purchases
- To make the E-rate application and other processes fast, simple, and efficient

Under the E-rate Modernization Order, the FCC has set aside a total of $5 billion in new funding in the next 5 years to support the construction of Wi-Fi services on school campuses and in libraries. More information on the E-rate Modernization Order is available at http://www.fcc.gov/document/fcc-releases-e-rate-modernization-order.

* Data retrieved from the Education and Library Networks Coalition (http://www.edlinc.org/get_facts.html#Is%20the%20E-Rate%20program%20working).

In addition to computers, mobile devices such as laptops, smartphones, and tablets are enhancing students' access to the Internet. Even though these Internet-connected devices have become one of the primary means with which youth interact and learn from each other, little national data are available to describe how and with what frequency these devices are used in day-to-day learning in and out of school (NTIA 2011).

Among high school students in 2013, 89% owned Internet-connected smartphones, 60% had laptops, and 50% had access to tablets (Project Tomorrow 2014). Teacher access to these devices has also risen dramatically: between 2008 and 2012, the percentage of teachers who owned a smartphone jumped from 20% to 67%, and the percentage who owned a tablet rose from 6% to 31% (Project Tomorrow 2013).

Digital Conversion

With the advent of Internet-connected mobile devices, schools and districts are also instigating what is called a *digital conversion* within their classrooms, replacing traditional hard-copy textbooks with interactive, multimedia digital textbooks or e-textbooks that are accessible to students through the Internet. The Speak Up National Survey, conducted by Project Tomorrow in 2012, found that some middle and high school teachers had already started capitalizing on the potential of this digital conversion, supplementing their teaching with videos (47%), digital textbooks (21%), animations (20%), online curricula (21%), simulations (10%), and virtual labs (6%) (Project Tomorrow 2013). The survey also found that mathematics and science teachers took the lead in the adoption of these new teaching strategies. Nevertheless, lacking computers or mobile devices is a major hindrance to digital conversion: 60% of school principals said that the lack of computers or devices with Internet access was a major obstacle to the greater adoption of digital content in their schools (Project Tomorrow 2014).

Distance Education and Online Courses

In addition to its potential for enhancing learning in the classroom, technology can also enable students to receive instruction remotely through distance education or online learning. Distance education may include videoconferencing and televised or audiotaped courses, but Internet courses (commonly referred to as *online learning*) are the most widespread and fastest-growing mode of delivery at the K–12 level. Online learning programs range from programs that are fully online with all instruction occurring via the Internet to hybrid or *blended learning* programs that combine face-to-face teacher instruction with online components (Picciano and Seaman 2009; Staker and Horn 2012; Watson et al. 2014).

During recent years, online learning at the K–12 level has grown rapidly in the United States. Online learning mainly occurred at the high school level; enrollment at this level accounted for 74% of the total K–12 distance-education enrollment in 2009–10. In 2009–10, there were an estimated 1,816,400 enrollments in distance-education courses in K–12 public school districts, representing a 473% increase from 317,100 distance-education enrollments in the 2002–03 school year (Snyder and Dillow 2013). As of 2013–14, a total of 30 states (including the District of Columbia) had statewide full-time online schools (Watson et al. 2014). Full-time enrollment in online schools has grown from approximately 200,000 students in 2009–10 to more than 315,000 in 2013–14 (iNACOL 2013; Watson et al. 2014). In addition, 26 states operated virtual schools in 2013–14, providing supplemental online courses to approximately 740,000 students nationwide (Watson et al. 2014). To put these changes in context, overall K–12 public enrollment increased by 2% in the same period, from 48,183,086 in fall 2002 to 49,360,982 in fall 2009 (Snyder and Dillow 2013).

A nationally representative survey of public school districts conducted by NCES in 2009 found that the top reasons for offering online learning opportunities were to provide courses not otherwise available at their schools (64%) and to give students opportunities to recover course credits from classes missed or failed (57%) (Queen and Lewis 2011). The survey also found that credit recovery was especially important in urban areas, where 81% of school districts indicated this was a very important reason for making online learning opportunities available. Other reasons school districts gave for providing online learning options included offering AP or college-level courses (40%), reducing scheduling conflicts for students (30%), and providing opportunities for homebound students and those with special needs (25%).

Research on Effectiveness of Instructional Technology and Online Learning

Effects of Instructional Technology

Existing research studies about the effects of instructional technology on student learning are not comprehensive enough to address the general question of whether technology yields improved student outcomes (Tamim et al. 2011). Few national studies are available; many of the existing studies were of brief duration or were based on specific products, small and geographically narrow samples, or weak research designs. To address these shortcomings, the Office of Educational Technology has issued a report outlining the problems with current research on digital education and providing a framework for how research evidence can be improved (U.S. Department of Education 2013a).

Nevertheless, several meta-analyses—studies that seek to combine data from nonrepresentative studies into a rigorous statistical design to provide limited but more rigorous findings—have yielded some promising findings. A large-scale meta-analysis summarized a total of 1,055 primary studies from 1967 to 2008 and concluded that the use of computer technologies in classrooms had positive (though small) effects on student achievement (Tamim et al. 2011).

Three meta-analyses that specifically focused on mathematics learning compared the mathematics achievement of students taught in elementary and secondary classes using technology-assisted mathematics programs with that of students in control classes using alternative programs or standard methods (Cheung and Slavin 2011; Li and Ma

2010; Rakes et al. 2010). All three studies found small, positive effects on student achievement when technology was incorporated into mathematics classes. A randomized impact evaluation found that a computer-aided application improved elementary students' mathematics test scores (Carrillo, Onofa, and Ponce 2010).

Cumulative evidence, again based on limited studies, suggests that technology's potential to improve student achievement may depend on how it is incorporated into instruction (Cennamo, Ross, and Ertmer 2013; Ross, Morrison, and Lowther 2010; Tamim et al. 2011). One study found that when computing devices were used as tools to supplement the traditional curriculum, no achievement increase was observed. When computing devices were used as main teaching tools in class, however, there was an increase in student achievement (Norris, Hossain, and Soloway 2012).

Effects of instructional technology may also vary with grade level. One study randomly selected middle and high schools across seven states either to adopt a technology-assisted algebra curriculum or continue with the traditional algebra curriculum (Pane et al. 2013). The study found that, although students in high schools with technology-assisted curricula performed better than their peers in schools with traditional curricula, such differences were not observed among students in middle schools.

Effects of Online Learning

Policymakers and researchers cite numerous potential benefits of online learning, which include increasing access to resources, personalizing learning, and assisting struggling students (Bakia et al. 2012; U.S. Department of Education 2010; Watson et al. 2013). Despite these potential benefits, few rigorous national studies have addressed the effectiveness of online learning compared with that of traditional school models at the K–12 level (Means et al. 2010). One small-scale study with a quasi-experimental design found that students participating in online learning performed as well as their peers in comparable classrooms that used traditional instruction (O'Dwyer, Carey, and Kleiman 2007). A meta-analysis of more than 500 studies addressing the effectiveness of online learning found that interactive distance education provided small and positive effects on student achievement compared to traditional classroom instruction (Bernard et al. 2004). Other recent studies also have observed some positive effects for online learning, but researchers stress that teacher training and the way in which online components are integrated into the curriculum are important variables that could affect outcomes and need to be the subject of more rigorous research (Norris, Hossain, and Soloway 2012; Tamim et al. 2011). The latest research suggests that distance education and online schools are meeting the needs of students who do not have access to adequate physical school and course options. However, research on the effectiveness of online learning is still in a nascent state (Watson et al. 2014).

Transition to Higher Education

One of the most important education goals in the United States is to educate every student to graduate from high school ready for college and a career (Achieve Inc. 2013; NCEE 2013; Pellegrino and Hilton 2012; The White House n.d.). Over the past decades, U.S. high school graduation rates have been rising steadily, surpassing 80% for the first time in U.S. history in 2012 (Balfanz et al. 2014).

High school completion represents a major milestone for adolescents, but skills acquired in high school are often insufficient qualifications for jobs that pay enough to support a family. In today's labor market, most of the fastest-growing, well-paying jobs require at least some postsecondary education (Carnevale, Smith, and Strohl 2010; Hout 2012). Given the competitive pressures associated with an increasingly global economy, young people who do not pursue education beyond high school face fewer job opportunities, lower earnings, and a greater likelihood of being unemployed and underemployed compared with their college-educated peers (Baum, Ma, and Payea 2013; Blossfeld et al. 2005; Pew Research Center 2014).

Within this context, this section focuses on indicators related to U.S. students' transitions from high school to postsecondary education. It presents national data on on-time high school graduation rates, long-term trends in immediate college enrollment after high school, choice of STEM majors at the postsecondary level, and academic preparation for college. This section also examines U.S. students' high school graduation and postsecondary entry rates relative to those of their peers in other countries. Together, these indicators present a broad picture of the transition of U.S. students from high school to postsecondary education. (Higher education in S&E is the topic of chapter 2.)

Completion of High School

Estimates of U.S. high school completion rates vary substantially, depending on the definitions, data sources, and methods used in their calculation (Heckman and LaFontaine 2007; Seastrom et al. 2006). Based on a relatively inclusive definition—receiving a regular high school diploma or earning an equivalency credential, such as a General Educational Development (GED) certificate—about 85% of the U.S. population ages 18–24 in 2012 had completed a high school education.[i] This is consistent with the experience of a nationally representative cohort of 2002 high school sophomores; 96% of the cohort members had earned a high school diploma or an equivalency credential by 2012 (Lauff and Ingels 2014).

Beginning with the 2011–12 school year, the U.S. Department of Education required all states to use a more restrictive definition of high school graduation, emphasizing on-time graduation and considering only recipients of regular high school diplomas (Chapman et al. 2011; Curran and Reyna 2010). Under this definition, the high school graduation rate is the percentage of students in a freshman class who graduate with a regular diploma 4 years after entering ninth grade (Stetser and Stillwell 2014).

Because calculating this rate requires following up with the same students over time, and because not all states had the longitudinal data necessary to compute this rate as of the 2011−12 school year, the U.S. Department of Education recommended using the averaged freshman graduation rate (AFGR) to estimate on-time high school graduation rates (Stetser and Stillwell 2014). The AFGR calculation divides the total number of high school diplomas in a particular year by the estimated size of the incoming freshman class 4 years earlier.[ii]

Although not as accurate as a 4-year graduation rate computed from a longitudinal cohort of students followed over time, the AFGR can be estimated with widely available cross-sectional data and is acknowledged by the U.S.

Department of Education as one of the most accurate indicators among several alternative measures that can be calculated using cross-sectional data (Seastrom et al. 2006). The U.S. high school graduation rates discussed below are AFGRs.

On-Time Graduation Rates from 2006 to 2012

The on-time graduation rate among U.S. public high school students has increased steadily since 2006 (Table 1-19). In 2006, 73% of public high school students graduated on time with a regular diploma; by 2012, the figure had climbed to 81%. Hispanic students made the largest gain during this period, an improvement of 15 percentage points, from 61% in 2006 to 76% in 2012. Black students improved as well, gaining 9 percentage points, from 59% in 2006 to 68% in 2012. In comparison, white students gained just 5 percentage points, and Asian or Pacific Islander students gained only 4 percentage points during this period. But substantial differences among racial and ethnic groups persisted: in 2012, the on-time high school graduation rates for Asian or Pacific Islander and white students were 93% and 85%, respectively; and both figures surpassed those of black, Hispanic, and American Indian or Alaska Native students (68%–76%).

---

[i]Data drawn from *Digest of Education Statistics 2013* (Snyder and Dillow 2015:42, table 104.40).

[ii] The incoming freshman class size is estimated by summing the enrollment in eighth grade for 1 year, ninth grade for the next year, and tenth grade for the year after, and then dividing by 3. For example, the 2011–12 on-time graduation rate equals the total number of diploma recipients in 2011–12 divided by the average membership of the eighth grade class in 2007–08, the ninth grade class in 2008–09, and the tenth grade class in 2009–10 (Stetser and Stillwell 2014).

Table 1-19 **On-time graduation rates of U.S. public high school students, by sex and race or ethnicity: 2006–12**

(Percent)

Sex and race or ethnicity	2006	2007	2008	2009	2010	2011	2012
All students	73.2	73.4	74.8	76.5	78.2	79.6	80.9
Sex							
Male	69.7	69.5	70.9	73.4	NA	77.0	78.0
Female	77.3	77.0	78.3	80.6	NA	84.0	85.0
Race or ethnicity[a]							
White	80.3	80.4	81.0	81.8	83.0	84.0	84.8
Black	59.2	59.0	61.4	63.6	66.1	66.5	67.7
Hispanic	61.0	60.8	63.4	67.0	71.4	74.7	76.1
Asian or Pacific Islander	89.3	89.6	91.4	93.0	93.5	92.6	93.3
American Indian or Alaska Native	61.8	60.9	64.4	64.2	69.1	68.2	68.4

NA = not available.

[a] Hispanic may be any race. American Indian or Alaska Native, Asian or Pacific Islander, black or African American, and white refer to individuals who are not of Hispanic origin.

SOURCE:	Stetser M, Stillwell R, *Public High School Four-Year On-Time Graduation Rates and Event Dropout Rates: School Years 2010–11 and 2011–12: First Look*, NCES 2014-391 (2014); Stillwell R, Sable J, *Public School Graduates and Dropouts from the Common Core of Data: School Year 2009–10: First Look*, NCES 2013-309rev (2013); Common Core Data Table Library, http://nces.ed.gov/ccd/tables/AFGR.asp and http://nces.ed.gov/ccd/tables/AFGR0812.asp, accessed October 2015.
	Science and Engineering Indicators 2016

Sex differences in on-time graduation rates have also persisted over time. In each year from 2006 through 2012, [iii] the percentage of male students who graduated from high school within 4 years was lower than that of female students. In 2012, the on-time graduation rate for male students lagged behind that for female students by 7 percentage points (78% versus 85%).

High School Graduation Rates in the United States and Other OECD Nations

OECD estimates upper secondary graduation rates for its members and selected nonmember countries by dividing the number of graduates in a country by the number of people at the typical graduation age (OECD 2014).[iv] These estimates enable a broad international comparison. [v]

U.S. graduation rates are lower than those of many OECD countries. Among the 28 OECD nations with available data on graduation rates in 2012, the United States ranked 22nd, with a graduation rate of 79%, compared with the OECD average of 84% (Appendix Table 1-30). The top-ranked countries include Slovenia, Iceland, Germany, the Netherlands, Hungary, Ireland, the United Kingdom, Japan, Spain, Finland, Denmark, and South Korea—all of which had graduation rates above 90%.

Furthermore, the relative standing of U.S. high school graduation rates has not changed much from 2006 to 2012. Among the 21 OECD countries for which graduation rate data were available in 2006, 2008, 2010, and 2012, the United States ranked 16th in 2006, 2008, and 2012 and 17th in 2010 (Table 1-20).

[iii] Sex data were not available in 2010.

[iv] Upper secondary education, as defined by OECD, corresponds to high school education in the United States. In the calculation of the U.S. graduation rates, OECD included only students who earned a regular diploma and excluded those who completed a GED certificate program or other alternative forms of upper secondary education. OECD defines the typical graduation age as the age of the students at the beginning of the school year: students will generally be 1 year older than the age indicated when they graduate at the end of the school year. According to OECD, the typical graduation age in the United States is 17 years old. The U.S. high school graduation rates calculated by OECD cannot be directly compared with U.S. on-time graduation rates because of the different population bases and calculation methods for the two measures.

[v] International comparisons are often difficult because of differences between education systems, types of degrees awarded across countries, and definitions used in different countries. Some researchers have pinpointed various problems and limitations of international comparisons and warned readers to interpret data, including those published by OECD, with caution (Adelman 2008; Wellman 2007).

Table 1-20 **Relative standing of U.S. high school graduation rates among OECD countries: 2006, 2008, 2010, and 2012**

Year and OECD country	Percent
2006	
Germany	103
Greece	100
Finland	95
Japan	93
South Korea	93
Norway	91
Czech Republic	90
Iceland	90
United Kingdom	88
Denmark	86
Ireland	86
Italy	86
Hungary	85
Slovakia	82
Poland	80
United States	**77**
Sweden	76
Luxembourg	72
Spain	72
Turkey	51
Mexico	42
2008	
Germany	97
Ireland	96
Japan	95
Finland	93
South Korea	93
Greece	91
Norway	91
United Kingdom	91
Iceland	89
Czech Republic	87
Italy	85

Year and OECD country	Percent
Denmark	83
Poland	83
Slovakia	81
Hungary	78
United States	**77**
Sweden	76
Luxembourg	73
Spain	73
Mexico	44
Turkey	26
2010	
Japan	96
Greece	94
South Korea	94
Ireland	94
Finland	93
United Kingdom	92
Iceland	88
Norway	87
Germany	87
Denmark	86
Hungary	86
Slovakia	86
Poland	84
Italy	83
Spain	80
Czech Republic	79
United States	**77**
Sweden	75
Luxembourg	70
Turkey	54
Mexico	47
2012	
Iceland	95

Year and OECD country	Percent
Germany	95
Hungary	94
Ireland	93
United Kingdom	93
Japan	93
Spain	93
Finland	93
Denmark	92
South Korea	92
Norway	88
Slovakia	86
Poland	85
Italy	84
Czech Republic	82
United States	**79**
Sweden	77
Greece	71
Luxembourg	69
Turkey	55
Mexico	47

OECD = Organisation for Economic Co-operation and Development.

NOTE: Data include only OECD countries with available data in all four years.

SOURCES: OECD, *Education at a Glance: OECD Indicators 2008* (2008), *Education at a Glance: OECD Indicators 2010* (2010), *Education at a Glance: OECD Indicators 2012* (2012), and *Education at a Glance: OECD Indicators 2014* (2014).

Science and Engineering Indicators 2016

Enrollment in Postsecondary Education

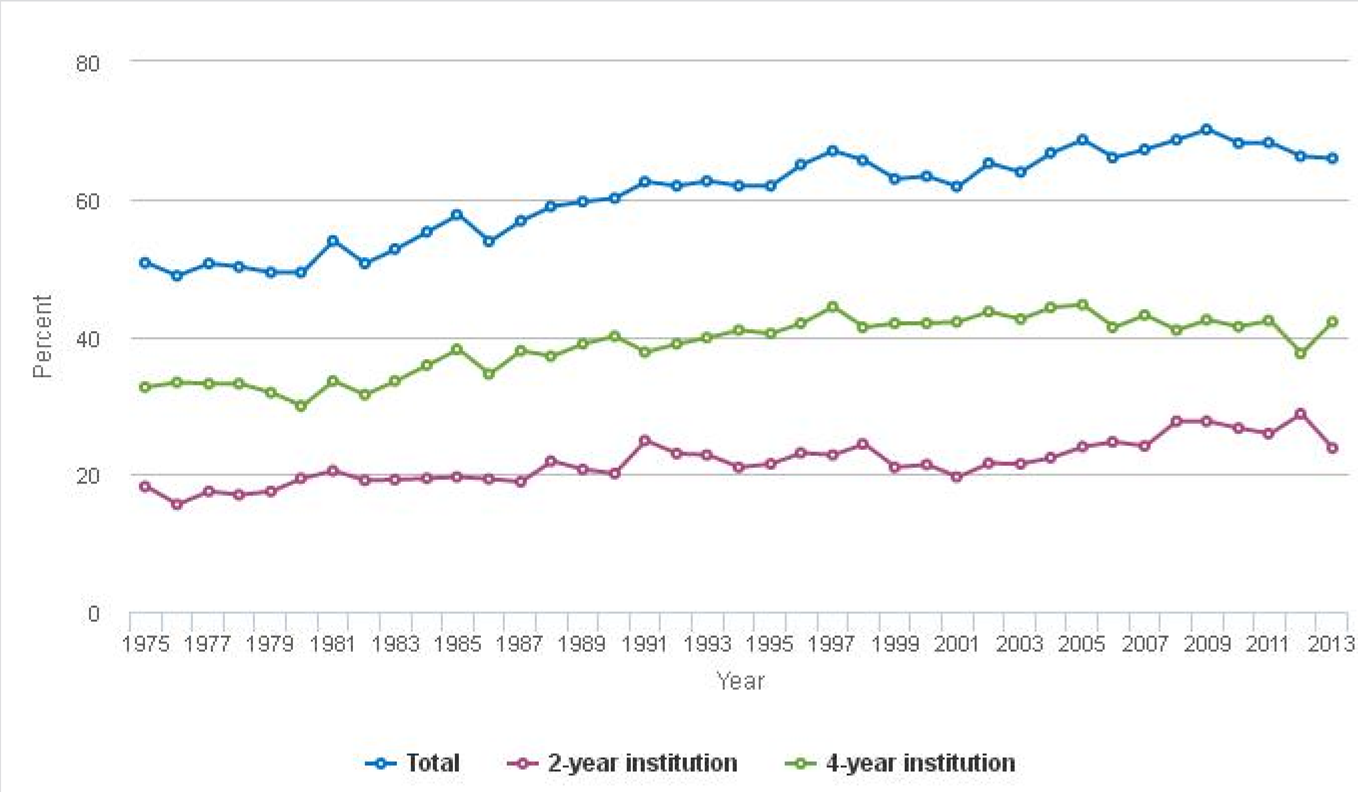
Although high school graduation represents the culmination of elementary and secondary schooling, it also marks a fundamental crossroads at which youth make critical choices about their future. Although some immediately enter the workforce, join the military, or start families, the majority of students go directly into postsecondary education (Ingels et al. 2012). Of the 3.2 million high school graduates in 2012, some 2.1 million (66%) enrolled in a 2- or 4-year college the following fall (Kena et al. 2014). This rate, known as the *immediate college enrollment rate,* is defined as the annual percentage of high school completers, including GED recipients, who enroll in 2- or 4-year colleges by the October following high school completion.

Between 1975 and 2013, the percentage of high school graduates making an immediate transition to college increased from 51% to 66%, although this upward trend peaked at 70% in 2009 and has decreased since then (

Figure 1-19). In each year, more students enrolled in 4-year institutions than in 2-year institutions. Immediate enrollment rates between 1975 and 2013 increased from 33% to 42% for 4-year institutions and from 18% to 24% for 2-year institutions. Between 1975 and 2013, immediate college enrollment was generally higher and rose faster for women (from 49% to 68%) than for men (from 53% to 64%) (Appendix Table 1-31). Since 1975, the immediate college enrollment rate has increased from 49% to 67% for white students, 45% to 57% for black students, and 53% to 66% for Hispanic students. Asians or Pacific Islanders enrolled at consistently higher rates than other groups since 2003, when data on Asian and Pacific Islander students were first available.

Figure 1-19

Immediate college enrollment rates among high school graduates, by institution type: 1975–2013



NOTES: Figure includes students ages 16–24 completing high school in survey year. Immediate college enrollment rates are defined as rates of high school graduates enrolled in college in October after completing high school. Before 1992, high school graduates referred to those who had completed 12 years of schooling. As of 1992, high school graduates are those who have received a high school diploma or equivalency certificate.

SOURCES: Digest of Education Statistics 2013 Data Table Library, tables 302.10, 302.20, 302.30, http://nces.ed.gov/programs/digest/2013menu_tables.asp, accessed November 2014. See appendix table 1-31.

Science and Engineering Indicators 2016

Large enrollment gaps, however, persisted among students of different socioeconomic backgrounds (Appendix Table 1-31): in 2013, the immediate college enrollment rate of students from low-income families was considerably lower than the rate of those from high-income families (46% versus 79%). Enrollment rates also varied widely with parental education, ranging in 2013 from 43% for students whose parents had less than a high school education to 83% for students whose parents had a bachelor's or higher degree.

Transition to STEM Fields

With the goals of maintaining global competitiveness and enhancing capacity for innovation, U.S. policymakers have called for increasing the number and diversity of students pursuing degrees and careers in STEM fields (NAS COSEPUP 2005; NGA 2007). Likewise, a recent policy report by the President's Council of Advisors on Science and Technology urged U.S. colleges and universities to increase the number of STEM graduates.

In 2011-12, some 23% of U.S. undergraduates were enrolled in STEM fields, including math/computer sciences (5%), natural sciences (6%), engineering (5%), and social/behavioral sciences (7%) (Table 1-21). About 18% of first-year students declared a STEM major upon entering college. The declaration of a STEM major in the first year of college was more common among males (26%) than among females (12%). The sex differences were particularly evident in mathematics or computer sciences (9% versus 2%) and engineering (9% versus 1%).

Table 1-21 **U.S. undergraduates who chose a STEM major, by demographic characteristics: Academic year 2011–12**

(Percent)

Demographic characteristic	STEM major, total	Specific STEM major: Math/ computer sciences	Natural sciences	Engineering	Social/ behavioral sciences
All undergraduates	22.6	4.7	5.9	4.9	7.1
First-year students	17.9	4.7	4.5	4.5	4.3
Sex					
Male	26.0	8.7	4.8	9.2	3.3
Female	11.7	1.6	4.2	0.9	5.1
Race or ethnicity[a]					
White	19.1	5.0	4.8	4.8	4.5
Black	13.8	4.1	2.9	3.1	3.7
Hispanic	16.8	3.9	4.0	4.5	4.4
Asian	27.1	6.1	9.0	8.0	4.0
Other	17.7	4.5	4.9	2.6	5.6
Parents' highest education					
High school education or less	15.4	4.6	3.8	3.6	3.4
Some college	17.0	4.6	3.9	3.8	4.7
Bachelor's degree or higher	21.8	4.5	6.0	6.1	5.3

STEM = science, technology, engineering, and mathematics.

[a] Hispanic may be any race. Asian, black or African American, white, and other races refer to individuals who are not of Hispanic origin.

NOTE: Percentages may not add to total because of rounding.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2014) of the 2011–12 National Postsecondary Student Aid Study (NPSAS:12), National Center for Education Statistics.

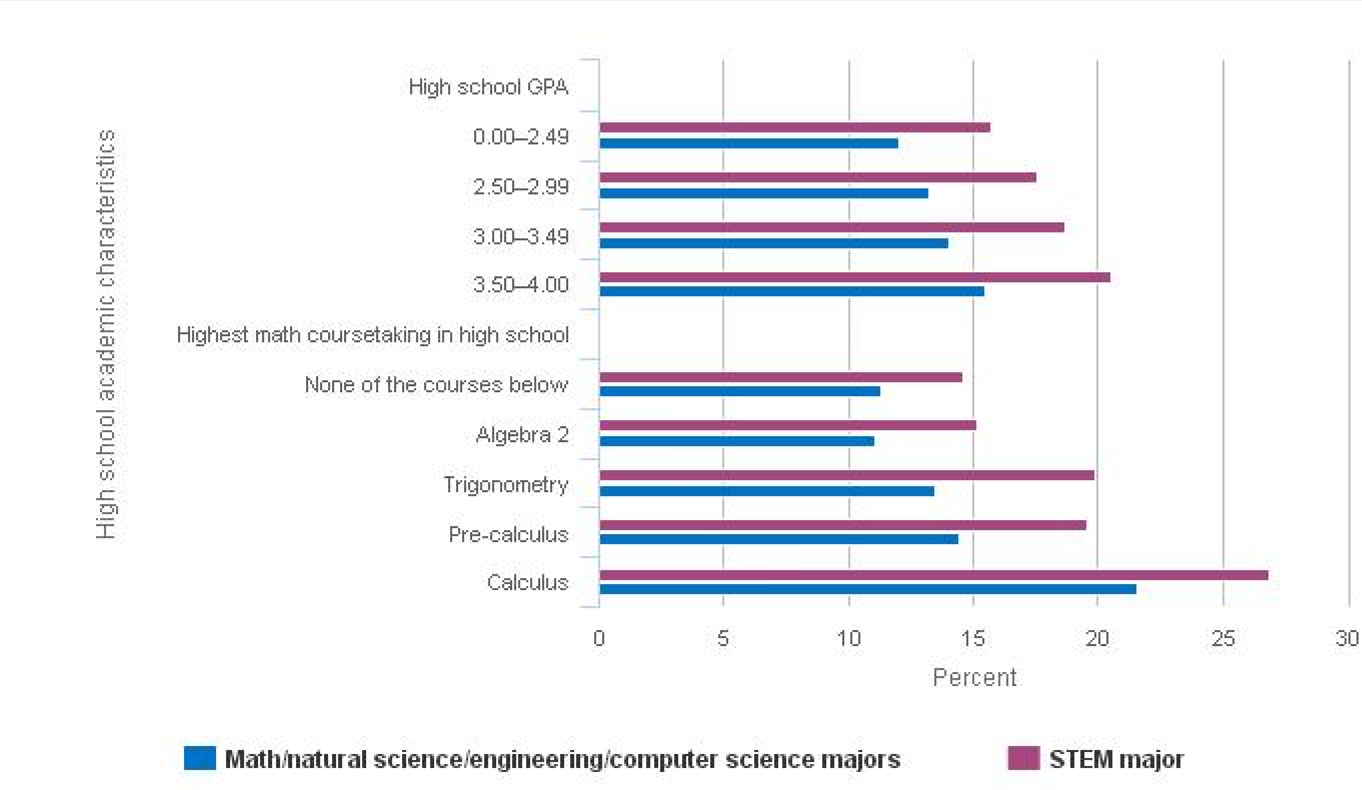
Science and Engineering Indicators 2016

Among all racial and ethnic groups, Asians and Pacific Islanders were the most likely to study STEM subjects. In 2011–12, 27% of Asian and Pacific Islander freshmen were enrolled in STEM fields, compared with 14%-19% of other racial and ethnic groups (Table 1-21). Higher parental education levels were associated with higher STEM enrollment rates: 15% of those with high school-educated parents and 22% of those whose parents had a bachelor's or higher degree enrolled in STEM fields.

For many students, the decision to study STEM has its beginnings before college, and high school academic preparation plays a critical role (Green and Sanderson 2014; Harris Interactive 2011; Moakler and Kim 2014; Tyson et al. 2007; Wang 2013). Among first-year college students in 2011-12, both high school mathematics coursetaking and cumulative grade point average (GPA) were linked to majoring in STEM (Figure 1-20). For example, among college freshmen under age 30, 27% of those who had taken calculus in high school chose a STEM major upon entering college, including 22% who chose a major in mathematics, natural sciences, engineering, or computer sciences. The corresponding figures for those who had not taken any mathematics beyond algebra 2 in high school were 15% and 11%, respectively. Additionally, 21% of freshmen under age 30 with a high school GPA of 3.5 or higher chose a STEM major after entering college, compared with 16% of those with a GPA below 2.0.

Figure 1-20

First-year college students who chose a STEM major, by selected high school academic characteristics: 2011–12



GPA = grade point average; STEM = science, technology, engineering, and mathematics.

NOTES: STEM major field includes mathematics, natural sciences, engineering, computer sciences, and social/behavioral sciences. Information on high school math coursetaking and GPA is not available for students age 30 or above (about 25% of all undergraduates in 2011–12).

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2014) of the 2011–12 National Postsecondary Student Aid Study (NPSAS:12), National Center for Education Statistics.

Science and Engineering Indicators 2016

Postsecondary Enrollment in an International Context

Participation in education beyond secondary schooling has been rising in many countries (Altbach, Reisberg, and Rumbley 2009; OECD 2014). One measure of such participation is the OECD-developed first-time entry rate into a university-level education program (referred to as a "tertiary-type A" program by OECD[i]). OECD calculates this entry rate by dividing the number of first-time entrants of a specific age in university-level education programs by the total population in the corresponding age group and then adding results for each single year of age. This calculation may result in very high entry rates (even higher than 100%) if an unexpected category of people (e.g., international students) decides to enter tertiary education in a particular country. This measure, though not perfect, provides a broad comparison of postsecondary enrollment rates in the United States and those in other OECD countries.

The percentage of American young adults enrolling in university-level education for the first time was 71% in 2012, surpassing the OECD average of 58% (Figure 1-21).[ii] The average age of persons enrolling for the first time was 23 in the United States and 22 in all OECD countries with available data (OECD 2014). The United States ranked eighth out of the 33 countries that participated in this study in 2012. Females enrolled in college at higher rates than males in many OECD countries, including the United States (Appendix Table 1-32). In 2012, U.S. women enrolled at a rate 15 percentage points higher than the rate for men (79% among women, compared with 64% among men). Among all OECD countries, 65% of women and 52% of men enrolled.

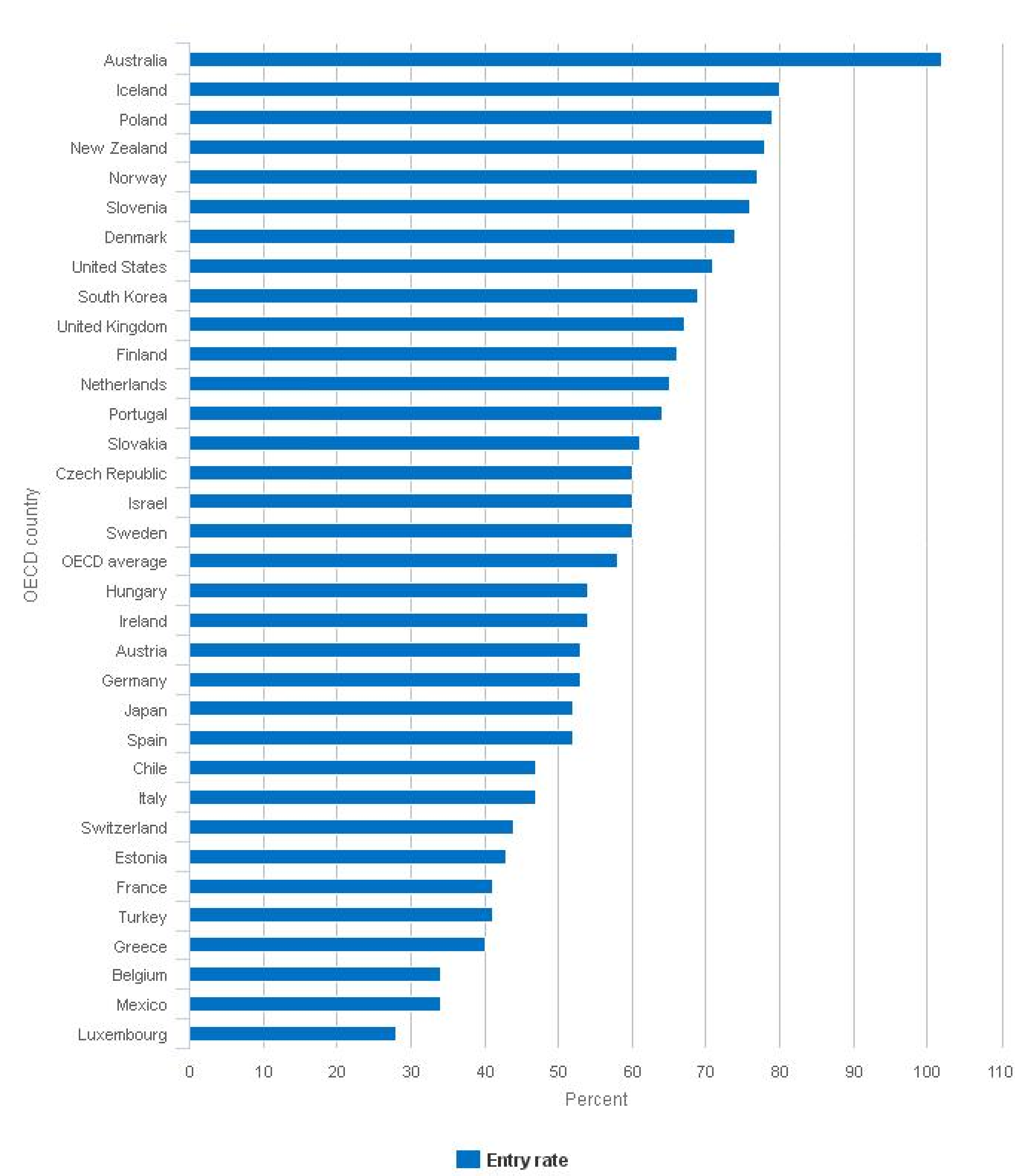
---

[i] As defined by OECD, a tertiary-type A program provides education that is largely theoretical and is intended to provide sufficient qualifications for gaining entry into advanced research programs and professions with high-skill requirements. Entry into these programs normally requires successful completion of upper secondary education (e.g., high school). Admission is competitive in most cases. Minimum cumulative duration at this level is 3 years of full-time enrollment.

[ii] OECD calculates entry rates by dividing number of first-time entrants of a specific age in each type of tertiary program by the total population in the corresponding age group and then adding results for each single year of age.

Figure 1-21

First-time entry rates into university-level education, by OECD country: 2012



OECD = Organisation for Economic Co-operation and Development.

NOTES: Countries/jurisdictions are ordered by 2012 first-time entry rate. Tied countries are listed alphabetically.

SOURCE: OECD, *Education at a Glance: OECD Indicators 2014* (2014). See appendix table 1-32.

Science and Engineering Indicators 2016

Preparation for College

Although more U.S. students than ever attend college after high school, many of them are not well prepared during their high school years for college, as evidenced by high rates of postsecondary remediation and low rates of college completion (Roderick, Nagaoka, and Coca 2009; Turner 2004). No direct measures of college readiness are available, and researchers' estimates often vary. Overall, knowledge about what constitutes being college ready and how to measure such readiness reliably remains elusive (Maruyama 2012; Roderick, Nagaoka, and Coca 2009) (see sidebar, Measuring College Readiness).

Measuring College Readiness

What does it mean to be college ready? How do we measure it? Addressing these questions requires clear definitions regarding the knowledge, skills, and attributes that students need to do well in college (Conley 2007). The current literature contains a wide range of definitions and assessments of college readiness, suggesting a lack of consensus about what constitutes being college ready or how to measure it. Nevertheless, recent work has made some progress on answering these questions. Drawing on past research, Roderick, Nagaoka, and Coca (2009) identified four areas of knowledge and skill development that are essential to college readiness:

- Content knowledge and basic skills (e.g., rules of grammar, concepts of science, spelling rules)
- Core academic skills (e.g., writing, analytic thinking, and problem-solving skills)
- Noncognitive skills (e.g., study skills, work habits, time management, and help-seeking behavior that reflect students' self-control, self-monitoring, and self-awareness)
- College knowledge (e.g., understanding college admissions and financial aid processes and college norms and culture)

Gaining access to and succeeding in college require students to have sufficient content knowledge, core academic skills, and noncognitive skills. Colleges traditionally evaluate their applicants' readiness by looking at high school transcripts to determine whether students have been exposed to content that prepares them for introductory college-level courses; achievement test scores to gauge whether students are equipped with adequate basic and core skills, content knowledge, and cognitive ability; and high school grade point average (GPA) to assess whether students have mastered class materials, have developed core academic skills, and possess the work effort and study habits critical to college success (Belfield and Crosta 2012; Kobrin 2007; Noble and Sawyer 2004; Stemler 2012). Thus, these indicators—high school coursetaking, achievement test scores (including college entrance exam scores), and GPA—are commonly recognized as the key components of college readiness (Greene and Winters 2005; Maruyama 2012).

In addition to these indicators, researchers argue that knowledge about college, or lack of such knowledge, may contribute to disparities in college success. Low-income and minority students who demonstrate the same academic qualifications as high-income and white students are less likely to attend selective 4-year institutions. Knowledge of the college application process, the financial aid system, and the range of choices within the postsecondary system may play a role in students' choices. Despite its importance, measuring "college knowledge" has not been fully addressed in national surveys (Roderick, Nagaoka, and Coca 2009).

The question of how to measure college readiness depends on what indicators are used and what outcomes are assessed—access to a 4-year institution, not needing remediation, success in first-year credit-bearing courses, and degree completion. To better measure college readiness, some researchers suggest that assessments of college readiness should use benchmarks with meaning and consequences for students (i.e., indicators tied to tangible consequence in higher education such as remedial course placement or receipt of course credits toward graduation); employ multiple and composite measures to maximize the accuracy of readiness information; and present readiness in terms of probabilities or likelihoods rather than as a single score designating a student as ready or not ready (Maruyama 2012). In sum, college readiness is multifaceted, encompassing not just academic preparation but also the knowledge, skills, attitudes, and behaviors necessary to gain access to college and overcome obstacles on the path to postsecondary success.

Conclusion

Raising overall student achievement, reducing performance gaps among different groups, and improving the international ranking of U.S. students on achievement tests are high priorities for education reform across the United States. How well does this country perform in these areas? The indicators in this chapter present a mixed picture of the status and progress of elementary and secondary mathematics and science education in the United States, both domestically and in international comparisons.

NAEP mathematics assessment results show that average mathematics scores for fourth and eighth graders improved slightly between 2000 and 2013, continuing a pattern of small but consistent increases. Overall mathematics scores for twelfth graders improved slightly between 2005 and 2013. Although the percentage of fourth, eighth, and twelfth grade students achieving a level of proficient or higher on NAEP assessments increased slightly between 2000 and 2013, those percentages stayed well below the 50% mark. Between-group differences in NAEP mathematics performance, based on parent education and race or ethnicity, have persisted over time but narrowed slightly since 1978. Overall, students from disadvantaged backgrounds continue to lag behind their more advantaged peers, with these disparities starting as early as kindergarten, as demonstrated in this chapter's analysis of ECLS-K:2011 kindergarten achievement data. Analysis of HSLS:09 assessment data shows similar patterns among the nation's eleventh graders. In the international arena, PISA data show that the U.S. average mathematics and science literacy scores are below the average scores for all developed countries. In addition, the United States appreciably underproduces students in the highest levels of mathematics achievement relative to other developed countries. It also moderately underproduces students in the highest levels of science achievement and, to an extent, overproduces students in the lowest levels of mathematics and science achievement.

Efforts to improve student achievement include raising high school graduation requirements, strengthening the rigor of curriculum standards, and increasing advanced coursetaking. These efforts have brought some positive changes, as shown in the discussion of student achievement in this chapter. Most states have adopted the Common Core State Standards, and the Next Generation Science Standards are bringing attention to the type of science education needed to keep the United States competitive in the world economy. The majority of high school students are on track to finish algebra 2 and basic science courses by the end of eleventh grade, and the number of students who take AP courses in mathematics and science continues to rise. There is still considerable room for improvement, however. The overall percentage of students taking mathematics and science AP tests remains small, and wide gaps among students from different socioeconomic backgrounds persist in regard to which students take more advanced courses during high school. Sex differences are negligible in the preponderance of mathematics and science achievement and coursetaking. These differences, however, become substantial in the most advanced AP courses and in high school courses in computer science and engineering.

Efforts to improve student achievement also focus on ensuring that all students have access to highly qualified teachers, although there is not a consensus on what constitutes a "highly qualified" teacher. The majority of K−12 mathematics and science teachers held a teaching certificate and had taught their subjects for 3 years or more. Indicators of in-field teaching and undergraduate coursework suggest that high school mathematics and science teachers were generally better prepared for their teaching subjects than were middle and elementary school teachers. Fully certified, well-prepared, and experienced teachers were not evenly distributed across schools or classes. Overall, schools or classes that had lower concentrations of non-Asian or Pacific Islander minority and low-income students and higher concentrations of high-achieving students were more likely to have fully certified and better-prepared mathematics and science teachers. Working conditions were also not evenly distributed across schools: high-poverty schools were more likely to suffer from various problems that inhibit effective teaching, including low student interest, high absenteeism, inadequate teacher preparation, and lack of materials and supplies.

Recent federal and state policies encourage greater use of technology throughout the education system as a way to improve students' learning experiences. The use of instructional technology in K−12 classrooms has been growing rapidly. Many school districts have invested in technology such as computers and mobile devices. The number of students participating in online learning courses is also rising, jumping from 317,000 in 2003 to an estimated 1.8 million in 2010. Rigorous research on the effects of instructional technology and online learning shows some modest positive effects on student mathematics learning, but far more research is needed to determine which technologies are effective and under what conditions.

Ensuring that students graduate from high school and are ready for college or the labor market is an important goal of high school education in the United States. Since 2006, the U.S. on-time high school graduation rates have improved steadily. In 2012, the vast majority of public high school students graduated with a regular diploma 4 years after entering ninth grade. Significant racial and ethnic and sex differences persisted, however, with white, Asian or Pacific Islander, and female students having higher graduation rates than their corresponding counterparts. In the broad international context, the United States ranked 22nd in graduation rates among 28 OECD countries with available data in 2012, and its relative standing has not changed in recent years.

The vast majority of high school seniors expect to attend college after completing high school, and many do so directly after high school graduation. Immediate college enrollment rates have increased for all students from 1975 to 2013. Large gaps persisted among students from different socioeconomic backgrounds. In 2013, the immediate college enrollment rate of students from low-income families was 33 percentage points lower than the rate of those from high-income families.

Glossary

Advanced Placement (AP): Courses that teach college-level material and skills to high school students who can earn college credits by demonstrating advanced proficiency on a final course exam. The curricula and exams for AP courses, available for a wide range of academic subjects, are developed by the College Board.

Blended learning: Any time a student learns at least in part at a supervised, traditional school location away from home and at least in part through online delivery with some element of student control over time, place, path, and /or pace; often used synonymously with "hybrid learning."

Developed country: A developed country, industrialized country, or "more economically developed country" (MEDC), is a sovereign state that has a highly developed economy and advanced technological infrastructure relative to other less industrialized nations. Most commonly, the criteria for evaluating the degree of economic development are gross domestic product (GDP), gross national product (GNP), the per capita income, level of industrialization, amount of widespread infrastructure and general standard of living. Which criteria are to be used and which countries can be classified as being developed are subjects of debate.

Developing country: A developing country, also called a lower developed country, is a nation with an underdeveloped industrial base, and low Human Development Index (HDI) relative to other countries.

Distance education: A mode of delivering education and instruction to students who are not physically present in a traditional setting such as a classroom. Also known as "distance learning," it provides access to learning when the source of information and the learners are separated by time and/or distance.

Elementary schools: Schools that have no grades higher than 8.

Eligibility for National School Lunch Program: Student eligibility for this program, which provides free or reduced-price lunches, is a commonly used indicator for family poverty. Eligibility information is part of the administrative data kept by schools and is based on parent-reported family income and family size.

English language learner: An individual who, due to any of the reasons listed below, has sufficient difficulty speaking, reading, writing, or understanding the English language to be denied the opportunity to learn successfully in classrooms where the language of instruction is English or to participate fully in the larger U.S. society. Such an individual (1) was not born in the United States or has a native language other than English; (2) comes from environments where a language other than English is dominant; or (3) is an American Indian or Alaska Native and comes from environments where a language other than English has had a significant effect on the individual's level of English language proficiency.

GED certificate: This award is received following successful completion of the General Educational Development (GED) test. The GED program, sponsored by the American Council on Education, enables individuals to demonstrate that they have acquired a level of learning comparable to that of high school graduates.

High school completer: An individual who has been awarded a high school diploma or an equivalent credential, including a GED certificate.

High school diploma: A formal document regulated by the state certifying the successful completion of a prescribed secondary school program of studies. In some states or communities, high school diplomas are differentiated by type, such as an academic diploma, a general diploma, or a vocational diploma.

High schools: Schools that have at least one grade higher than 8 and no grade in K–6.

Middle schools: Schools that have any of grades 5–8 and no grade lower than 5 and no grade higher than 8.

Online learning: Education in which instruction and content are delivered primarily over the Internet.

Organisation for Economic Co-operation and Development (OECD): An international organization of 34 countries headquartered in Paris, France. The member countries are Australia, Austria, Belgium, Canada, Chile, Czech Republic, Estonia, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, South Korea, Luxembourg, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom, and United States. Among its many activities, the OECD compiles social, economic, and science and technology statistics for all member and selected non-member countries.

Postsecondary education: The provision of a formal instructional program with a curriculum designed primarily for students who have completed the requirements for a high school diploma or its equivalent. These programs include those with an academic, vocational, or continuing professional education purpose and exclude vocational and adult basic education programs.

Professional development: In-service training activities designed to help teachers improve their subject matter knowledge, acquire new teaching skills, and stay informed about changing policies and practices.

Remedial courses: Courses taught within postsecondary education that cover content below the college level.

Repeating cross-sectional studies: This type of research focuses on how a specific group of students performs in a particular year, and then looks at the performance of a similar group of students at a later point in time. An example would be comparing fourth graders in 1990 to fourth graders in 2011 in NAEP.

Scale score: Scale scores place students on a continuous achievement scale based on their overall performance on the assessment. Each assessment program develops its own scales.

References

Achieve Inc. 2008. The building blocks of success: Higher-level math for all students. Washington, DC. http://www.achieve.org/files/BuildingBlocksofSuccess.pdf. Accessed February 2015.

Achieve Inc. 2013. Closing the expectations gap: 2013 annual report on the alignment of state K–12 policies and practices with the demands of college and careers. Washington, DC. www.achieve.org/ClosingtheExpectationsGap2013. Accessed February 2015.

Adamson F, Darling-Hammond L. 2012. Funding disparities and the inequitable distribution of teachers: Evaluating sources and solutions. *Education Policy Analysis Archives* 20(37).

Adelman C. 2008. The propaganda of international comparisons. *Inside Higher Ed* (15 December). https://www.insidehighered.com/views/2008/12/15/adelman. Accessed February 2015.

Alliance for Excellent Education. 2011. Digital learning and technology: Federal policy recommendations to seize the opportunity and promising practices that inspire them. http://all4ed.org/wp-content/uploads/2013/06/DigitalLearning.pdf. Accessed May 2015.

Altbach PG, Reisberg L, Rumbley LE. 2009. Trends in global higher education: Tracking an academic revolution. Paris: UNESCO. http://unesdoc.unesco.org/images/0018/001831/183168e.pdf. Accessed November 2014.

American Association for the Advancement of Science (AAAS). 1993. *Benchmarks for Science Literacy*. New York: Oxford University Press.

American Federation of Teachers (AFT). 2008. Survey and analysis of teacher salary trends 2007. Washington, DC. http://www.aft.org/sites/default/files/salarysurvey07.pdf. Accessed May 2015.

Aritomi P, Coopersmith J. 2009. Characteristics of public school districts in the United States: Results from the 2007–08 Schools and Staffing Survey. NCES 2009-320. Washington, DC: National Center for Education Statistics.

Atkinson RD, Mayo M. 2010. Refueling the U.S. innovation economy: Fresh approaches to science, technology, engineering and mathematics (STEM) education. Washington, DC: Information Technology and Innovation Foundation. http://www.itif.org/publications/refueling-us-innovation-economy-fresh-approaches-stem-education. Accessed May 2015.

Bakia M, Shear L, Toyama Y, Lasseter A. 2012. Understanding the implications of online learning for educational productivity. Washington, DC: U.S. Department of Education, Office of Educational Technology.http://www.sri.com/sites/default/files/publications/implications-online-learning.pdf. Accessed November 2014.

Balfanz R, Bridgeland JM, Fox JH, DePaoli JL, Ingram ES, Maushard M. 2014. Building a grad nation: Progress and challenge in ending the high school dropout epidemic. http://gradnation.org/sites/default/files/17548_BGN_Report_FinalFULL_5.2.14.pdf. Accessed May 2015.

Banilower ER, Smith PS, Weiss IR, Malzahn KM, Campbell KM, Weis AM. 2013. Report of the 2012 National Survey of Science and Mathematics Education. Chapel Hill, NC: Horizon Research, Inc. http://www.horizon-research.com/2012nssme/research-products/reports/technical-report/. Accessed May 2015.

Baum S, Ma J, Payea K. 2013. Education pays 2013: The benefits of higher education for individuals and society. New York: College Board. http://trends.collegeboard.org/sites/default/files/education-pays-2013-full-report.pdf. Accessed November 2014.

Belfield CR, Crosta PM. 2012. Predicting success in college: The importance of placement tests and high school transcripts. CCRC Working Paper No. 42. New York: Columbia University, Teachers College, Community College Research Center. http://files.eric.ed.gov/fulltext/ED529827.pdf. Accessed November 2014.

Bernard RM, Abrami PC, Lou Y, Borokhovski E, Wozney L, Wallet PA, Fiset M, Huang B. 2004. How does distance education compare with classroom instruction? A meta-analysis of the empirical literature. *Review of Educational Research* 74(3):379–439.

Berry B, Eckert J. 2012. Creating teacher incentives for school excellence and equity. Boulder, CO: National Education Policy Center.

Blossfeld H-P, Klijzing E, Mills M, Kurz K. 2005. *Globalization, Uncertainty and Youth in Society: The Losers in a Globalizing World*. New York: Routledge.

Boonen T, Van Damme J, Onghena P. 2014. Teacher effects on student achievment in first grade: Which aspects matter most? *School Effectiveness and School Improvement* 25(1):126–52.

Boyd D, Grossman P, Lankford H, Loeb S, Wyckoff J. 2006. How changes in entry requirements alter the teacher workforce and affect student achievement. *Education Finance and Policy* 1(2):176–215.

Boyd D, Grossman P, Lankford H, Loeb S, Wyckoff J. 2008. Teacher preparation and student achievement. Washington, DC: National Center for the Analysis of Longitudinal Data in Education Research. Urban Institute. http://www.urban.org/UploadedPDF/1001255_teacher_preparation.pdf. Accessed May 2015.

Bozick R, Lauff E. 2007. Education Longitudinal Study of 2002 (ELS:2002): A first look at the initial postsecondary experiences of the sophomore class of 2002. NCES 2008-308. Washington, DC: National Center for Education Statistics.

Buddin R, Zamarro G. 2009a. Teacher qualifications and middle school student achievement. RAND Working Paper WR-671-IES. Santa Monica, CA: RAND Education. http://www.rand.org/content/dam/rand/pubs/working_papers/2009/RAND_WR671.pdf. Accessed May 2015.

Buddin R, Zamarro G. 2009b. Teacher qualifications and student achievement in urban elementary schools. Santa Monica, CA: RAND Corporation. http://www.rand.org/pubs/reprints/RP1410.html. Accessed May 2015.

Byun S, Irvin MJ, Bell BA. 2014. Advanced math course taking: Effects on math achievement and college enrollment. *Journal of Experimental Education.* http://dx.doi.org/10.1080/00220973.2014.919570. Accessed December 2014.

Campbell P, Malkus, N. 2011. The impact of elementary mathematics coaches on student achievement. *Elementary School Journal* 111(3):430–54.

Carnevale AP, Smith N, Strohl J. 2010. Help wanted: Projections of jobs and education requirements through 2018. Washington, DC: Georgetown University Center on Education and the Workforce. https://cew.georgetown.edu/report/help-wanted/. Accessed May 2015.

Carrillo P, Onofa M, Ponce J. 2010. Information technology and student achievement. IDB Working Paper Series IDB-WP-223. Washington, DC: Inter-American Development Bank.

Cennamo K, Ross J, Ertmer P. 2013. *Technology Integration for Meaningful Classroom Use: A Standards-Based Approach*. 2nd ed. Belmont, CA: Wadsworth.

Chapman C, Laird J, Ifill N, KewalRamani A. 2011. Trends in high school dropout and completion rates in the United States: 1972–2009. NCES 2012-006. Washington, DC: National Center for Education Statistics.

Cheung ACK, Slavin RE. 2011. The effectiveness of educational technology applications for enhancing mathematics achievement in K–12 classrooms: A meta-analysis. Baltimore, MD: Best Evidence Encyclopedia, Johns Hopkins University School of Education, Center for Data-Driven Reform in Education. http://www.bestevidence.org/word/tech_math_Sep_09_2011.pdf. Accessed November 2014.

Chingos MM, Peterson PE. 2011. It's easier to pick a good teacher than to train one: Familiar and new results on the correlates of teacher effectiveness. *Economics of Education Review* 30(3):449–65.

College Board. 2014. The 10th annual AP report to the nation. New York. http://media.collegeboard.com/digitalServices/pdf/ap/rtn/10th-annual/10th-annual-ap-report-to-the-nation-single-page.pdf. Accessed April 2015.

Computer Science Teachers Association (CSTA). 2014. Results from the CSTA-Oracle Academy 2014 U.S. High School CS Survey: The state of computer science in U.S. high schools: An administrator's perspective. http://csta.acm.org/Research/sub/Projects/2014_StateofCSinUSHighSchools.pdf. Accessed February 2015.

Conger D, Long MC, Iatarola P. 2009. Explaining race, poverty, and gender disparities in advanced course-taking. *Journal of Policy Analysis and Management* 28(4):555–76.

Conley DT. 2007. Redefining college readiness. Eugene, OR: Educational Policy Improvement Center. http://www.aypf.org/documents/RedefiningCollegeReadiness.pdf. Accessed November 2014.

Council of Chief State School Officers (CCSSO). 2009. Effects of teacher professional development on gains in student achievement: How meta analysis provides scientific evidence useful to education leaders. Washington, DC. http://www.ccsso.org/Documents/2009/Effects_of_Teacher_Professional_2009.pdf. Accessed May 2015.

Creemers B, Kryiakides L, Antoniou P. 2013. *Teacher Professional Development for Improving Quality of Teaching.* Dordrecht, The Netherlands: Springer.

Curran B, Reyna R. 2010. Implementing graduation counts: State progress to date, 2010. Washington, DC: National Governors Association Center for Best Practices. http://www.nga.org/files/live/sites/NGA/files/pdf/1012GRADCOUNTSPROGRESS.PDF. Accessed May 2015.

Davis EA, Petish D, Smithey J. 2006. Challenges new science teachers face. *Review of Educational Research* 76(4):607–51.

DeMonte J. 2013. High-quality professional development for teachers: Supporting teacher training to improve student learning. Washington, DC: Center for American Progress.

Desimone LM, Smith TM, Ueno K. 2006. Are teachers who need sustained, content-focused professional development getting it? An administrator's dilemma. *Educational Administration Quarterly* 42(2):179–215.

Duffey DR, Fox C. 2012. National educational technology trends 2012: State leadership empowers educators, transforms teaching and learning. Washington, DC: State Educational Technology Directors Association. http://files.eric.ed.gov/fulltext/ED536746.pdf. Accessed November 2014.

Eckert SA. 2013. What do teaching qualificiations mean in urban schools? A mixed-methods study of teacher preparation and qualification. *Journal of Teacher Education* 64(1):75–89.

Federal Communications Commission (FCC). 2010. E-rate program and broadband usage survey: Report. FCC DA 10-2414. Washington, DC: Federal Communications Commission Wireline Competition Bureau. http://transition.fcc.gov/010511_Eratereport.pdf. Accessed November 2014.

Feng L. 2014. Teacher placement, mobility, and occupational choices after teaching. *Education Economics* 22(1):24–47.

Fox C, Waters J, Fletcher G, Levin D. 2012. The broadband imperative: Recommendations to address K–12 education infrastructure needs. Washington, DC: State Educational Technology Directors Association. http://www.setda.org/wp-content/uploads/2013/09/Broadband_Trifold.pdf. Accessed May 2015.

Gaertner MN, Kim J, DesJardins SL, McClarty KL. 2014. Preparing students for college and careers: The causal role of algebra II. *Research in Higher Education* 55(2):143–65.

Gamoran A, Hannigan EC. 2000. Algebra for everyone? Benefits of college-preparatory mathematics for students with diverse abilities in early secondary school. *Educational Evaluation and Policy Analysis* 22(3):241–54.

Gansle KA, Noell GH, Burns JM. 2012. Do student achievement outcomes differ across teacher preparation programs? An analysis of teacher education in Louisiana. *Journal of Teacher Education* 63(5):304–17.

Gardner DP. 1983. A nation at risk. Washington, DC: National Commission on Excellence in Education, U.S. Department of Education.

Garet M, Porter AC, Desimone LM, Birman B, Yoon K. 2001. What makes professional development effective? Analysis of a national sample of teachers. *American Educational Research Journal* 38(3):915–45.

Gersten R, Taylor MJ, Keys TD, Rolfhus E, Newman-Gonchar R. 2014. Summary of research on the effectiveness of math professional development approaches. Washington, DC: National Center for Education Evaluation and Regional Assistance.

Gilpin GA. 2012. Teacher salaries and teacher aptitude: An analysis using quantile regressions. *Economics of Education Review* 31:15–29.

Goldhaber D, Krieg J, Theobald R, Brown N. 2014. The STEM and special education teacher pipelines: Why don't we see better alignment between supply and demand? CEDR Working Paper 2014-3. Seattle, WA: Center for Education Data & Research.

Goldhaber D, Liddle S, Theobald R. 2013. The gateway to the profession: Assessing teacher preparation programs based on student achievement. *Economics of Education Review* 34(2):29–44.

Gray L, Thomas N, Lewis L. 2010a. Educational technology in U.S. public schools: Fall 2008. NCES 2010-034. Washington, DC: National Center for Education Statistics. http://nces.ed.gov/pubs2010/2010034.pdf. Accessed December 2014.

Gray L, Thomas N, Lewis L. 2010b. Teachers' use of educational technology in U.S. public schools: 2009. NCES 2010-040. Washington, DC: National Center for Education Statistics. http://nces.ed.gov/pubs2010/2010040.pdf. Accessed December 2014.

Green A, Sanderson D. 2014. Steps to success: An analysis of persistence and attainment in STEM majors. http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2451256. Accessed May 2015.

Greene JP, Winters MA. 2005. Public high school graduation and college-readiness rates: 1991–2002. New York: Manhattan Institute for Policy Research, Center for Civic Innovation. http://www.manhattan-institute.org/html/ewp_08.htm. Accessed November 2014.

Gruber KJ, Wiley SD, Broughman SP. 2002. Schools and Staffing Survey, 1999−2000: Overview of the data for public, private, public charter, and Bureau of Indian Affairs elementary and secondary schools. NCES 2002-313. Washington, DC: National Center for Education Statistics.

Guarino C, Dieterle SG, Bargagliotti AE, Mason WM. 2013. What can we learn about effective early mathematics teaching? A framework for estimating causal effects using longitudinal survey data. *Journal of Research on Educational Effectiveness* 6(2):164–98.

Hanushek EA. 2011. The economic value of higher teacher quality. *Economics of Education Review* 30(3):466–79.

Hanushek EA, Rivkin SG. 2006. Teacher quality. *In* Hanushek EA, Welch F, editors, *Handbook of the Economics of Education*. Vol. 2, pp. 1051–78. Amsterdam: North Holland.

Hanushek EA, Rivkin SG. 2007. Pay, working conditions, and teacher quality. *Excellence in the Classroom* 17(1):69–86. http://hanushek.stanford.edu/sites/default/files/publications/Hanushek%2BRivkin%202007%20Future%20of%20Children%2017%281%29.pdf. Accessed May 2015.

Harris A, Muijs D. 2004. *Improving Schools Through Teacher Leadership*. Maidenhead, United Kingdom: McGraw-Hill.

Harris DN, Sass TR. 2007. Teacher training, teacher quality, and student achievement. National Center for the Analysis of Longitudinal Data in Education Research Working Paper #3. Washington, DC: Urban Institute.

Harris DN, Sass TR. 2011. Teacher training, teacher quality and student achievement. *Journal of Public Economics* 95(7–8):798–812.

Harris Interactive. 2011. STEM perceptions: Student & Parent Study. Rochester, NY: Harris Interactive.

Heckman JJ, LaFontaine PA. 2007. The American high school graduation rate: Trends and levels. Working Paper 13670. Cambridge, MA: National Bureau of Economic Research.

Heitin L. 2014a. Common science standards slow to catch on in states. *Education Week* (28 January). http://www.edweek.org/ew/articles/2014/01/29/19science_ep.h33.html. Accessed December 2014.

Heitin L. 2014b. Next generation science standards: Which states adopted and when? *Education Week* (15 August). http://www.edweek.org/ew/articles/2014/01/29/19science_ep.h33.html. Accessed December 2014.

Heller JI, Daehler KR, Wong N, Shinohara M, Miratrix LW. 2012. Differential effects of three professional development models on teacher knowledge and student achievement in elementary science. *Journal of Research in Science Teaching* 49(3):333–62.

Henry GT, Bastian KC, Fortner CK, Kershaw DC, Purtell KM, Thompson CL, Zulli RA. 2014. Teacher preparation policies and their effects on student achievement. *Education Finance and Policy* 9(3):264–303.

Hill JG, Dalton B. 2013. Student math achievement and out-of-field teaching. *Educational Researcher* 42(7):403–5.

Hill JG, Gruber KJ. 2011. Education and certification qualifications of departmentalized public high school-level teachers of core subjects: Evidence from the 2007−08 Schools and Staffing Survey. NCES 2011-317. Washington, DC: National Center for Education Statistics.

Hobbs L. 2015. Teaching science out-of-field. *In* Gunstone R, editor, *Encyclopedia of Science Education,* pp. 1044–8. New York: Springer Reference.

Horrigan JB. 2014. Schools and broadband speeds: An analysis of gaps in access to high-speed internet for African American, Latino, low-income, and rural students. Washington, DC: Alliance for Excellent Education and the LEAD Commission. http://99in5.org/wp-content/uploads/2014/12/Schools-and-Broadband-Speeds-Final.pdf. Accessed December 2014.

Hout M. 2012. Social and economic returns to college education in the United States. *Annual Review of Sociology* 38:379–400.

Ingels SJ, Dalton B. 2013. High School Longitudinal Study of 2009 (HSLS:09) First follow-up: A first look at fall 2009 ninth-graders in 2012. NCES 2014-360. Washington, DC: National Center for Education Statistics.

Ingels SJ, Glennie E, Lauff E, Wirt JG. 2012. Trends among young adults over three decades, 1974–2006. NCES 2012-345. Washington, DC: National Center for Education Statistics.

Ingels SJ, Pratt DJ, Herget DR, Burns LJ, Dever JA, Ottem R, Rogers JE. 2011. High School Longitudinal Study of 2009 (HSLS:09): Base-year data file documentation. NCES 2011-328. Washington, DC: National Center for Education Statistics.

Ingersoll R, Strong M. 2011. The impact of induction and mentoring programs for beginning beginning teachers: A critical review of the research. *Review of Education Research* 81(2):201–33.

Ingersoll RM. 2011. Do we produce enough mathematics and science teachers? *Phi Delta Kappan* 92(6):37–41.

Ingersoll RM, May H. 2012. The magnitude, destinations, and determinants of mathematics and science teacher turnover. *Educational Evaluation and Policy Analysis* 34(4):435–64.

International Association for Online K-12 Learning (iNACOL). 2013. Fast facts about online learning. Vienna, VA: iNACOL. http://www.inacol.org/resource/fast-facts-about-online-learning/. Accessed November 2014.

Jackson CK, Rockoff JE, Staiger DO. 2014. Teacher effects and teacher-related policies. *Annual Review of Economics* 6:801–25.

Jacob A. 2012. Examining the relationship between student achievement and observable teacher characteristics: Implications for school leaders. *International Journal of Educational Leadership Preparation* 7(3).

Jaeger PT, McClure CR, Bertot JC. 2005. The E-rate program and libraries and library consortia, 2000–2004: Trends and issues. *Information Technology and Libraries* 24(2):57–67.

James L, Pate J, Leech D, Martin E, Brockmeier L, Dees E. 2011. Resource allocation patterns and student achievement. *International Journal of Educational Leadership Preparation* 6(4).

Johnson L, Adams Becker S, Estrada V, Freeman A. 2014. NMC Horizon Report: 2014 K–12 edition. Austin, TX: New Media Consortium. http://cdn.nmc.org/media/2014-nmc-horizon-report-k12-EN.pdf. Accessed May 2015.

Johnson SM, Kraft MA, Papay JP. 2012. How context matters in high-need schools: The effects of teachers' working conditions on their professional satisfaction and their students' achievement. *Teachers College Record* 114(10):1–39.

Kena G, Aud S, Johnson F, Wang X, Zhang J, Rathbun A, Wilkinson-Flicker S, Kristapovich P. 2014. The condition of education 2014. NCES 2014-083. Washington, DC: National Center for Education Statistics.

Klein A. 2014. Historic summit fueled push for K–12 standards. *Education Week* (23 September).http://www.edweek.org/ew/articles/2014/09/24/05summit.h34.html?tkn=VRMFTfeHKsO04DXwCG2aKQNHf6HfwIKQcCLh&intc=es. Accessed December 2014.

Kobrin JL. 2007. Determining SAT® benchmarks for college readiness. RN-30. New York: College Board. http://research.collegeboard.org/sites/default/files/publications/2012/7/researchnote-2007-30-sat-benchmarks-college-readiness.pdf. Accessed May 2015.

Kraft MA, Papay JP. 2014. Can professional environments in school promote teacher development? Explaining heterogeneity in returns to teaching experience. *Educational Evaluation and Policy Analysis* 36(4):476–500.

Ladd HF. 2011. Teachers' perceptions of their working conditions: How predictive of planned and actual teacher movement? *Educational Evaluation and Policy Analysis* 33(2):235–61.

Ladd HF, Sorensen LC. 2014. Returns to teacher experience: Student achievement and motivation in middle school. Working Paper 112. Washington, DC: National Center for Analysis of Longitudinal Data in Education Research.

Lauff E, Ingels SJ. 2014. Education Longitudinal Study of 2002 (ELS:2002): A first look at 2002 high school sophomores 10 years later. NCES 2014-363. Washington, DC: National Center for Education Statistics.

Leak JA, Farkas G. 2011. Effects of teacher credentials, coursework, and certification on student achievement in math and reading in kindergarten: An ECLS-K study. Evanston, IL: Society for Research on Educational Effectiveness.

Lee J. 2012. Educational equity and adequacy for disadvantaged minority students: School and teacher resource gaps toward national mathematics proficiency standard. *Journal of Educational Research* 105(1):64–75.

Leigh A. 2012. Teacher pay and teacher aptitude. *Economics of Education Review* 31:41–53.

Li Q, Ma X. 2010. A meta-analysis of the effects of computer technology on school students' mathematics learning. *Educational Psychology Review* 22(3):215–43.

Linek WM, Sampson MB, Haas L, Sadler D, Moore L, Nylan MC. 2012. The impact of teacher preparation: A study of alternative certification and traditionally prepared teachers in their first year of teaching. *Issues in Teacher Education* 21(2):67–82.

Loeb S, Bassok D. 2007. Early childhood and the achievement gap. *In* Ladd HF and Fiske EB, editors, *Handbook of Research in Education Finance and Policy*, pp. 517–34. Oxford, UK: Routledge.

Loeb S, Kalogrides D, Béteille T. 2012. Effective schools: Teacher hiring, assignment, development, and retention. *Education* 7(3):269–304.

Loehr JF, Almarode JT, Tai RH, Sadler PM. 2012. High school and college biology: A multi-level model of the effects of high school courses on introductory course performance. *Journal of Biological Education* 46(3):165–72.

LoGerfo L, Christopher EM, Flanagan KD. 2012. High School Longitudinal Study of 2009 (HSLS:09): A first look at fall 2009 ninth-graders' parents, teachers, school counselors, and school administrators. NCES 2011-355. Washington DC: National Center for Education Statistics.

Long MC, Conger D, Iatarola P. 2012. Effects of high school coursetaking on secondary and postsecondary success. *American Educational Research Journal* 49(2):285–322.

Magnuson K, Duncan GJ. 2006. The role of family socioeconomic resources in the black-white test score gap among young children. *Developmental Review* 26(4):365–99.

Maruyama G. 2012. Assessing college readiness: Should we be satisfied with ACT or other threshold scores? *Educational Researcher* 41(7):252–61.

Means B, Toyama Y, Murphy R, Bakia M, Jones K. 2010. Evaluation of evidence-based practices in online learning: A meta-analysis and review of online learning studies. Washington, DC: U.S. Department of Education, Office of Planning, Evaluation, and Policy Development. http://www2.ed.gov/rschstat/eval/tech/evidence-based-practices/finalreport.pdf. Accessed May 2015.

Milanowski A. 2008. Using occupational characteristics information from O*NET to identify occupations for compensation comparisons with K–12 teaching. WCER Working Paper 2008-4. Madison, WI: Wisconsin Center for Education Research. http://www.wcer.wisc.edu/publications/workingpapers/Working_Paper_No_2008_04.pdf. Accessed May 2015.

Miller R, Roza M. 2012. The sheepskin effect and student achievement: De-emphasizing the role of master's degrees in teacher compensation. Washington DC: Center for American Progress. https://cdn.americanprogress.org/wp-content/uploads/issues/2012/07/pdf/miller_masters.pdf. Accessed June 2015.

Mo Y, Singh K, Chang M. 2013. Opportunity to learn and student engagement: A HLM study on eight grade science achievement. *Educational Research for Policy and Practice* 12(1):3–19.

Moakler MW, Kim MM. 2014. College major choice in STEM: Revisiting confidence and demographic factors. *Career Development Quarterly* 62(2):128–42.

Morton BA, Peltola P, Hurwitz MD, Orlofsky GF, Strizek GA. 2008. Education and certification qualifications of departmentalized public high school-level teachers of core subjects: Evidence from the 2003–04 Schools and Staffing Survey. NCES 2008-338. Washington, DC: National Center for Education Statistics.

Mulligan GM, Hastedt S, McCarroll, JC. 2012. First-time kindergartners in 2010–11: First findings from the kindergarten rounds of the Early Childhood Longitudinal Study, Kindergarten Class of 2010–11 (ECLS-K:2011). NCES 2012-049. Washington, DC: National Center for Education Statistics.

National Academy of Sciences, Committee on Science, Engineering, and Public Policy (NAS COSEPUP). 2005. Rising above the gathering storm: Energizing and employing America for a brighter economic future. Washington, DC: National Academies Press. http://www.nap.edu/catalog/11463/rising-above-the-gathering-storm-energizing-and-employing-america-for. Accessed May 2015.

National Assessment Governing Board (NAGB). 2010. Mathematics framework for the 2011 National Assessment of Educational Progress. Washington, DC. http://www.nagb.org/content/nagb/assets/documents/publications/frameworks/math-2011-framework.pdf. Accessed May 2015.

National Association of State Boards of Education (NASBE). 2012. Born in another time: Ensuring educational technology meets the needs of students today and tomorrow. Arlington, VA. http://www.nasbe.org/wp-content/uploads/Born-in-Another-Time-NASBE-full-report.pdf. Accessed May 2015.

National Center on Education and the Economy (NCEE). 2013. What does it really mean to be college and work ready? The mathematics required of first year community college students. Washington, DC: NCEE. http://www.ncee.org/wp-content/uploads/2013/05/NCEE_MathReport_May20131.pdf. Accessed May 2015.

National Center on Teacher Quality (NCTQ). 2011. State teacher policy yearbook: National summary. Washington, DC: NCTQ. http://www.nctq.org/dmsView/2011_State_Teacher_Policy_Yearbook_National_Summary_NCTQ_Report. Accessed February 2015.

National Center on Teacher Quality (NCTQ). 2013. State teacher policy yearbook: National summary. Washington, DC: NCTQ. http://www.nctq.org/dmsView/2013_State_Teacher_Policy_Yearbook_National_Summary_NCTQ_Report. Accessed February 2015.

National Council of Teachers of Mathematics (NCTM). 1989.Curriculum and evaluation standards for school mathematics. Reston, VA.

National Council of Teachers of Mathematics (NCTM). 2000. Principles and standards for school mathematics. Reston, VA.

National Governors Association (NGA). 2007. Building a science, technology, engineering and math agenda. Washington, DC: NGA. http://www.nga.org/files/live/sites/NGA/files/pdf/0702INNOVATIONSTEM.PDF. Accessed May 2015.

National Research Council (NRC). 1996. National science education standards. Washington, DC: National Academies Press.

National Research Council (NRC). 2013. Monitoring progress toward successful K–12 STEM education: A nation advancing? Committee on the Evaluation Framework for Successful K–12 STEM Education. Board on Science Education and Board on Testing and Assessment, Division of Behavioral and Social Sciences and Education. Washington, DC: National Academies Press.

National Science Board (NSB). 2010. *Science and Engineering Indicators 2010.* NSB 10-01. Arlington, VA: National Science Foundation. http://www.nsf.gov/statistics/seind10/pdf/seind10.pdf. Accessed May 2015.

National Science Board (NSB). 2012. *Science and Engineering Indicators 2012*. NSB 12-01. Arlington, VA: National Science Foundation. http://www.nsf.gov/statistics/seind12/pdf/seind12.pdf. Accessed May 2015.

National Science Board (NSB). 2014. *Science and Engineering Indicators 2014*. NSB 14-01. Arlington, VA: National Science Foundation. http://www.nsf.gov/statistics/seind14/content/etc/nsb1401.pdf. Accessed May 2015.

National Telecommunications and Information Administration (NTIA). 2011. *Digital nation: Expanding internet usage*. Washington, DC: U.S. Department of Commerce. http://www.ntia.doc.gov/files/ntia/publications/ntia_internet_use_report_february_2011.pdf. Accessed May 2015.

Ng W, Nicholas H, Williams A. 2010. School experience influences on pre-service teachers' evolving beliefs about effective teaching. *Teaching and Teacher Education* 26(2):278–89.

Noble JP, Sawyer RL. 2004. Is high school GPA better than admission test scores for predicting academic success in college? *College and University* 79(4):17–22.

Nord C, Roey S, Perkins R, Lyons M, Lemanski N, Tamir Y, Brown J, Schuknect J. 2011. America's high school graduates: Results from the 2009 NAEP High School Transcript Study. NCES 2011-462. Washington, DC: National Center for Education Statistics.

Norris C, Hossain A, Soloway E. 2012. Under what conditions does computer use positively impact student achievement? Supplemental vs. essential use. *In* Resta P, editor, *Proceedings of Society for Information Technology & Teacher Education International Conference 2012,* pp. 2021–8. Chesapeake, VA: Association for the Advancement of Computing in Education.

O'Dwyer LM, Carey R, Kleiman G. 2007. A study of the effectiveness of the Louisiana Algebra I online course. *Journal of Research on Technology in Education* 39(3):289–306.

Organisation for Economic Co-operation and Development (OECD). 2009. *PISA Data Analysis Manual: SAS®.* 2nd ed. Paris: OECD.

Organisation for Economic Co-operation and Development (OECD). 2014. *Education at a Glance 2014: OECD Indicators*. Paris: OECD. http://www.oecd.org/edu/Education-at-a-Glance-2014.pdf. Accessed May 2015.

Organisation for Economic Co-operation and Development (OECD). 2015. *Results from PISA 2012: United States country note.* Paris: OECD. http://www.oecd.org/pisa/keyfindings/PISA-2012-results-US.pdf. Accessed May 2015.

Pane JF, Griffin BA, McCaffrey DF, Karam R. 2013. Effectiveness of cognitive tutor Algebra I at scale. RAND Working Paper WR-984-DEIES. Santa Monica, CA: RAND Education. http://www.siia.net/visionk20/files/Effectiveness%20of%20Cognitive%20Tutor%20Algebra%20I%20at%20Scale.pdf. Accessed May 2015.

Pellegrino J, Hilton M. 2012. *Education for Life and Work: Developing Transferable Knowledge and Skills in the 21st Century*. Washington, DC: National Academies Press. http://www.nap.edu/catalog/13398/education-for-life-and-work-developing-transferable-knowledge-and-skills. Accessed May 2015.

Pew Research Center. 2014. The rising cost of not going to college. http://www.pewsocialtrends.org/2014/02/11/the-rising-cost-of-not-going-to-college. Accessed May 2015.

Picciano AG, Seaman J. 2009. K–12 online learning: A 2008 follow-up of the Survey of U.S. School District Administrators. Newburyport, MA: Sloan Consortium. http://www.onlinelearningsurvey.com/reports/k-12-online-learning-2008.pdf. Accessed May 2015.

President's Council of Advisors on Science and Technology (PCAST). 2012. Engage to excel: Producing one million additional college graduates with degrees in science, technology, engineering, and mathematics. Washington, DC: PCAST. http://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast-executive-report-final_2-13-12.pdf. Accessed May 2015.

Project Tomorrow. 2013. From chalkboards to tablets: The digital conversion of the K-12 classroom. Irvine, CA. http://www.tomorrow.org/speakup/pdfs/SU12EducatorsandParents.pdf. Accessed May 2015.

Project Tomorrow. 2014. Trends in digital learning: Students' views on innovative classroom models. Irvine, CA. http://www.tomorrow.org/speakup/2014_OnlineLearningReport.html. Accessed June 2015.

Queen B, Lewis L. 2011. Distance education courses for public elementary and secondary school students: 2009–10. NCES 2012-008. Washington, DC: National Center for Education Statistics.

Rakes CR, Valentine JC, McGatha MB, Ronau RN. 2010. Methods of instructional improvement in algebra: A systematic review and meta-analysis. *Review of Educational Research* 80(3):372–400.

Rentner DS, Kober N. 2014. Common Core State Standards in 2014: Districts' perceptions, progress, and challenges. Washington, DC: Center on Education Policy. http://www.cep-dc.org/displayDocument.cfm?DocumentID=440. Accessed December 2014.

Rice JK. 2013. Learning from experience? Evidence on the impact and distribution of teacher experience and the implications for teacher policy. *Education Finance and Policy* 8(3):332–48.

Richardson V, Placier P. 2001. Teacher change. *In* Richardson V, editor, *Handbook of Research on Teaching,* 4th ed., pp. 905–47. New York: Macmillan.

Richey RC. 2008. Reflections on the 2008 AECT definitions of the field. *Tech Trends* 52(1):24–5.

Roderick M, Nagaoka J, Coca V. 2009. College readiness for all: The challenge for urban high schools. *Future of Children* 19(1):185–210. http://www.princeton.edu/futureofchildren/publications/docs/19_01_09.pdf. Accessed May 2015.

Ronfeldt M. 2012. Where should student teachers learn to teach? Effects of field placement school characteristics on teacher retention and effectiveness. *Educational Evaluation and Policy Analysis* 34(1):3–26.

Ronfeldt M, Reininger M. 2012. More or better student teaching? *Teaching and Teacher Education* (28):1091–1106.

Rose R. 2012. The relationship of compensation to job attraction and performance in public schools. *Issues in Educational Research* 22(2):180–95.

Ross SM, Morrison GR, Lowther DL. 2010. Educational technology research past and present: Balancing rigor and relevance to impact school learning. *Contemporary Educational Technology* 1(1):17–35.

Salazar T, Christie K. 2014. States and the (not so) new standards—Where are they now? Denver, CO: Education Commission of the States.

Sass TR. 2011. Certification requirements and teacher quality: A comparison of alternative routes to teaching. CALDER Working Paper 64. Washington, DC: National Center for Analysis of Longitudinal Data in Education Research.

Sass TR, Hannaway J, Xu Z, Figlio DN, Feng L. 2012. Value added of teachers in high-poverty schools and lower poverty schools. *Journal of Urban Economics* 72(2):104–22.

Schmidt, WH, Houang RT, Cogan L, Blömeke S, Tatto MT, Hsieh FJ, Santillan M, Bankov K, Han S, Cedillo T, Schwille J, Paine L. 2008. Opportunity to learn in the preparation of mathematics teachers: Its structure and how it varies across six countries. *ZDM* 40(5):735–47.

Schweig J. 2014. Cross-level measurement invariance in school and classroom environment surveys: Implications for policy and practice. *Educational Evaluation and Policy Analysis* 36(3):259–80.

Seastrom MM, Chapman C, Stillwell R, McGrath D, Peltola P, Dinkes R, Xu Z. 2006. User's guide to computing high school graduation rates, Volume 1: Review of current and proposed graduation indicators. NCES 2006-604. Washington, DC: National Center for Education Statistics.

Shen J, Leslie JM, Spybrook JK, Ma X. 2012. Are principal background and school processes related to teacher job satisfaction? A multilevel study using Schools and Staffing Survey 2003–04. *American Educational Research Journal* 49(2):200–30.

Shepard L, Hannaway J, Baker E, editors. 2009. Standards, assessments, and accountability. Washington, DC: National Academy of Education. http://files.eric.ed.gov/fulltext/ED531138.pdf. Accessed December 2014.

Shober AF. 2012. From teacher education to student progress: Teacher quality since NCLB. Washington, DC: American Enterprise Institute.

Snyder TD, Dillow SA. 2011. *Digest of Education Statistics 2010.* NCES 2011-015. Washington, DC: National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education.

Snyder TD, Dillow SA. 2013. *Digest of Education Statistics 2012.* NCES 2014-015. Washington, DC: National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education.

Snyder TD, Dillow SA. 2015. *Digest of Education Statistics 2013.* NCES 2015-011. Washington, DC: National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education.

Staker H, Horn MB. 2012. Classifying K–12 blended learning. San Mateo, CA: Innosight Institute. http://www.christenseninstitute.org/wp-content/uploads/2013/04/Classifying-K-12-blended-learning.pdf. Accessed May 2015.

Stemler SE. 2012. What should university admissions tests predict? *Educational Psychologist* 47(1):5–17.

Stetser MC, Stillwell R. 2014. Public high school four-year on-time graduation rates and event dropout rates: School years 2010–11 and 2011–12. First look. NCES 2014-391. Washington, DC: National Center for Education Statistics.

Stronge JH, Ward TJ, Grant LW. 2011. What makes good teachers good? A cross-case analysis of the connection between teacher effectiveness and student achievement. *Journal of Teacher Education* 62(4):339–55.

Sung P-F, Yang M-L. 2013. Exploring disciplinary background effect on social studies teachers' knowledge and pedagogy. *Journal of Educational Research* 106(1):77–88.

Tamim RM, Bernard RM, Borokhovski E, Abrami PC, Schmid RF. 2011. What forty years of research says about the impact of technology on learning: A second-order meta-analysis and validation study. *Review of Educational Research* 81(1):4–28.

Taylor LL. 2008. Comparing teacher salaries: Insights from the U.S. Census. *Economics of Education Review* 27(1):48–57.

Teach for America. 2013. 2012–2013 Teach for America Annual Letter. Durham, NC. https://www.teachforamerica.org/sites/default/files/teach_for_america_fy12-13_annual_letter.pdf. Accessed February 2015.

Thomas N, Marken S, Gray L, Lewis L. 2013. Dual credit and exam-based courses in US public high schools: 2010–11: First look. NCES 2013-001. Washington DC: National Center for Education Statistics.

Turner S. 2004. Going to college and finishing college. Explaining different educational outcomes. *In* Hoxby CM, editor, *College Choices: The Economics of Where to Go, When to Go, and How to Pay for It,* pp. 13–62. Chicago: University of Chicago Press.

Tyson W. 2011. Modeling engineering degree attainment using high school and college physics and calculus coursetaking and achievement. *Research Journal for Engineering Education* 100(4):760–77.

Tyson W, Lee R, Borman KM, Hanson MA. 2007. Science, technology, engineering and mathematics (STEM) pathways: High school science and math coursework and postsecondary degree attainment. *Journal of Education for Students Placed at Risk* 12(3):243–70.

Ujifusa A. 2014. Days apart, two states opt to replace Common Core. *Education Week* (6 June). http://www.edweek.org/ew/articles/2014/06/06/35commonore.h33.html. Accessed December 2014.

United Nations Educational, Scientific and Cultural Organization (UNESCO). 2014. Education for all global monitoring report. Paris. http://unesdoc.unesco.org/images/0022/002256/225660e.pdf. Accessed April 2015.

U.S. Department of Education. 2010. Transforming American education: Learning powered by technology. Washington, DC: Office of Educational Technology. http://tech.ed.gov/wp-content/uploads/2013/10/netp2010.pdf. Accessed May 2015.

U.S. Department of Education. 2013a. Expanding evidence approaches for learning in a digital world. Washington, DC: Office of Educational Technology. http://tech.ed.gov/files/2013/02/Expanding-Evidence-Approaches.pdf. Accessed May 2015.

U.S. Department of Education. 2013b. Preparing and credentialing the nation's teachers: The Secretary's ninth report on teacher quality. Washington, DC.

U.S. Department of Education, National Center for Education Statistics, Common Core of Data (CCD). 2015. State Nonfiscal Survey of Public Elementary/Secondary Education, 1990–91 through 2012–13; and State Public Elementary and Secondary Enrollment Projection Model, 1980 through 2024. http://nces.ed.gov/programs/coe/indicator_cga.asp#info. Accessed August 2015.

U.S. Department of Labor, Bureau of Labor Statistics (DOL/BLS). 2013. Employment by industry, occupation, and percent distribution, 2012 and projected 2022; Computer systems design and related services. http://www.bls.gov/emp/ind-occ-matrix/ind_xls/ind_541500.xls. Accessed August 2015.

Walsh K, Jacobs S. 2007. Alternative certification isn't alternative. Washington, DC: Thomas B. Fordham Institute. http://www.nctq.org/p/publications/docs/Alternative_Certification_Isnt_Alternative_20071124023109.pdf. Accessed May 2015.

Wang J, Odell SJ, Clift RT. 2010. *Past, Present, and Future Research on Teacher Induction: An Anthology for Researchers, Policy Makers, and Practitioners*. Lanham, MD: Rowman and Littlefield.

Wang X. 2013. Why students choose STEM majors: Motivation, high school learning, and postsecondary context of support. *American Educational Research Journal* 50(5):1081–1121.

Watson J, Pape L, Murin A, Gemin B, Vashaw L. 2013. Keeping pace with K–12 online and blended learning: An annual review of policy and practice. Durango, CO: Evergreen Education Group. http://www.kpk12.com/wp-content/uploads/EEG_KP2013-lr.pdf. Accessed May 2015.

Watson J, Pape L, Murin A, Gemin B, Vashaw L. 2014. Keeping pace with K–12 digital learning: An annual review of policy and practice. Durango, CO: Evergreen Education Group. http://www.kpk12.com/wp-content/uploads/EEG_KP2014-fnl-lr.pdf. Accessed December 2014.

Weiss S. 2000. Setting the standard: Will higher expectations improve student achievement? Denver, CO: Education Commission of the States. http://www.ecs.org/clearinghouse/16/50/1650.pdf. Accessed December 2014.

Wellman JV. 2007. Apples and oranges in the flat world: A layperson's guide to international comparisons of postsecondary education. Washington, DC: American Council on Education. http://www.acenet.edu/news-room/Documents/Apples-Oranges-Guide-Intl-Comparisons-Postsecondary-Ed.pdf. Accessed December 2014.

The White House. n.d. ConnectED initiative. http://www.whitehouse.gov/issues/education/k-12/connected. Accessed May 2015.

Wilson SM. 2011. How can we improve teacher quality? *Phi Delta Kappan* 93(2):64–7.

Wiswall M. 2013. The dynamics of teacher quality. *Journal of Public Economics* 100:61–78.

Zietz J, Joshi P. 2005. Academic choice behavior of high school students: Economic rationale and empirical evidence. *Economics of Education Review* 24(3):297–308.

Zinth J. 2015. Computer science in high school graduation requirements. Denver, CO: Education Commission of the States. http://www.ecs.org/clearinghouse/01/18/29/11829.pdf. Accessed June 2015.